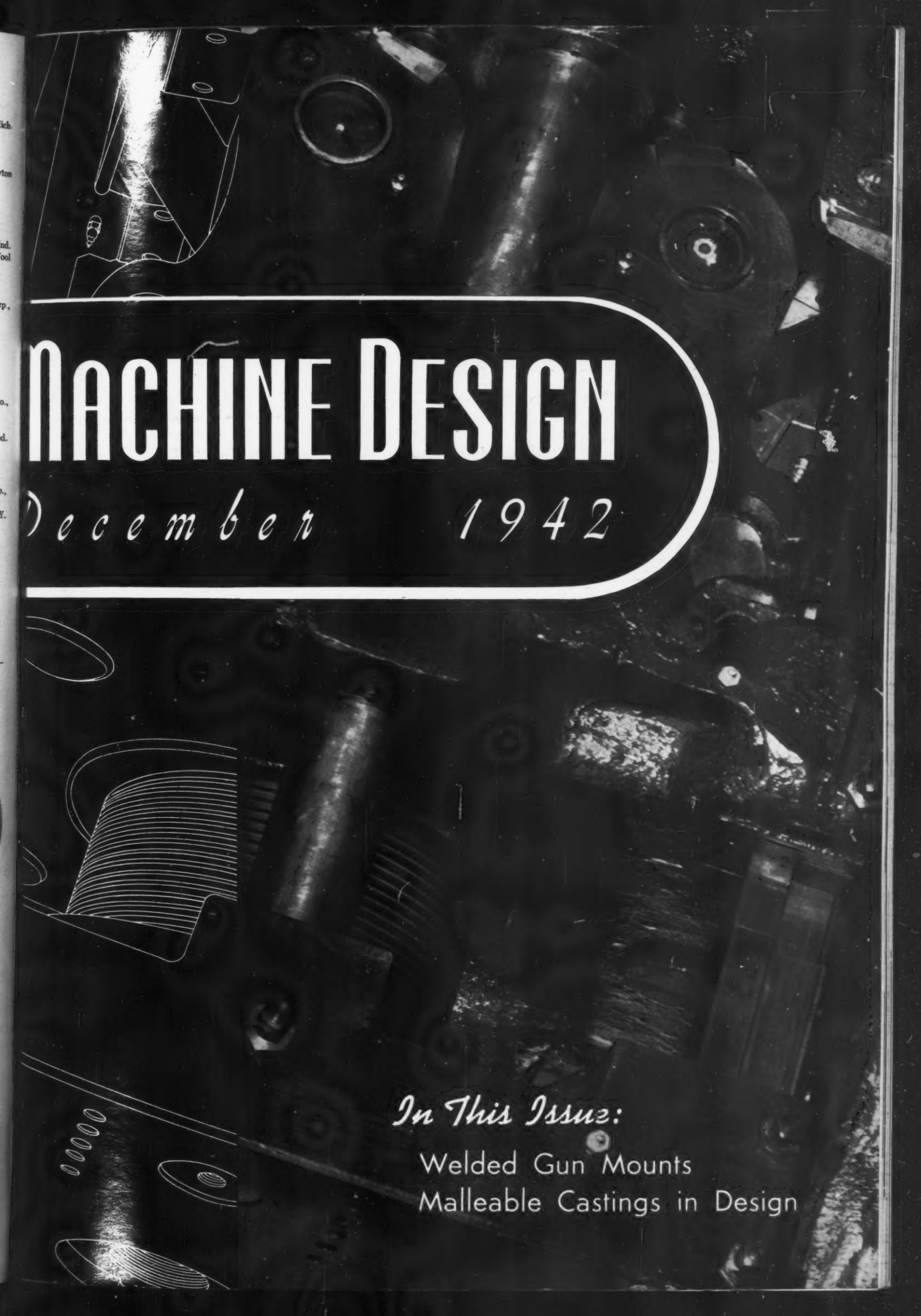


MACHINE DESIGN

December 1942

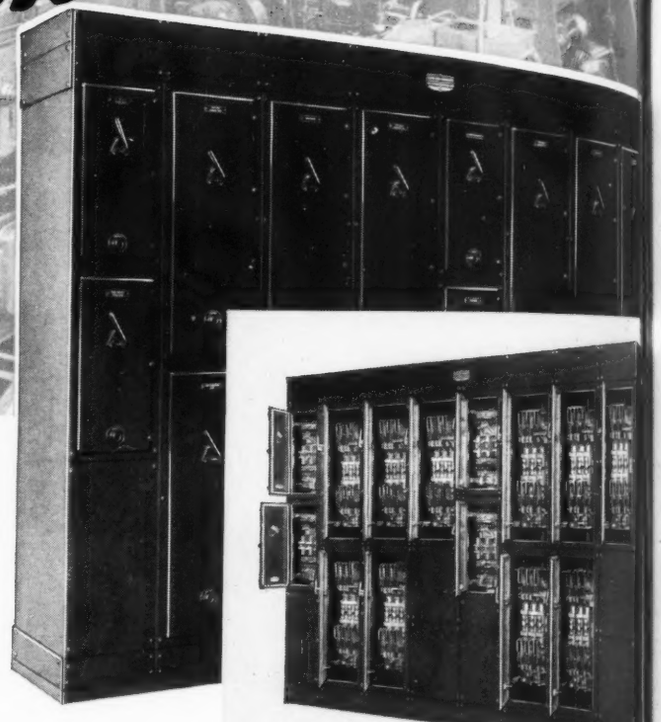
In This Issue:

Welded Gun Mounts

Malleable Castings in Design

With Speed, Space and Production the cry—

Let the Modern UNITROL



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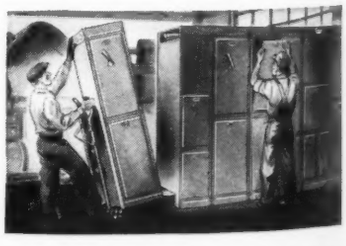

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 14 DECEMBER, 1942 Number 12

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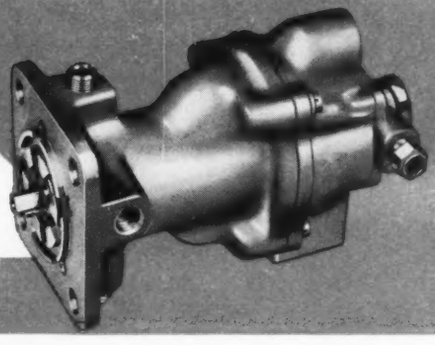

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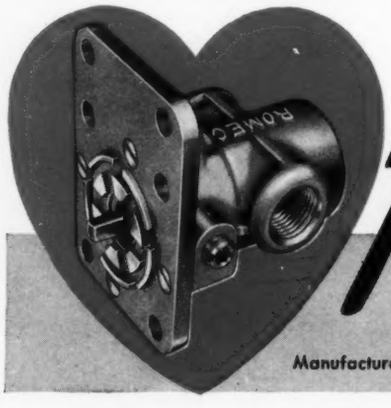

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Use Your Oxy-Acetylene Cutting Blowpipes *to* HELP GET IN THE SCRAP!

To help bring in the large amounts of steel and iron scrap so essential to continued high levels of steel production, your oxy-acetylene cutting blowpipes can be used to good advantage. This is true because large tonnages of potential scrap are to be found in obsolete machines, structural shapes, pipe, old boilers, and other pieces too bulky or heavy to be moved conveniently. With oxy-acetylene cutting blowpipes, such material can quickly be cut up for easy handling and disposal. In addition, scrap that is cut to charging box size usually brings higher prices that will more than repay the cost of cutting up. Outlined here are some suggestions that may help you in making available the largest amount of scrap in the least time and with highest returns for your effort.

1. **Explore Your Plant and Property,** and appoint someone to ear-mark every piece of machinery and equipment that can be spared for scrap.
2. **Contact Your Local Scrap Dealer or Salvage Committee** and find out to what lengths the scrap should be cut for highest returns.
3. **Classify and Segregate** alloy steels and other special materials—including copper—whenever it is desirable. Make provisions for doing this during scrapping operations.*
4. **Centralize Your Scrapping Operations** as much as possible. This will speed up the work, will minimize lost motion and rehandling, and also will tie up less equipment and fewer oxygen and acetylene cylinders.
5. **Utilize Local Welding Shops** if you are not equipped to do your own oxy-acetylene cutting.
6. **Move Scrap Fast** when it is ready. Sell it to a scrap dealer—turn it over to your local salvage committee—or give it to a local charity. But get it in!

*To help you identify metals for efficient classification of your scrap, we will be glad to send you without charge as many copies as you need of the wall chart, "Identifying Metals by Spark Testing." *Ask for Form 4666.* Another useful chart that you can obtain from any Linde office is, "Simple Tests for Identifying Metals by Appearance, Chip Test, and Blowpipe Test." *Ask for Form 2299-D.*

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The BIG JOB

FOR Formica, as for many other companies, the essential task right now is to supply the front with war materials. Everything we have is going into that and it will continue to be our big job for the duration.

But so far we have been able to care for many users of building and furniture sheet, electrical insulation, chemically resistant parts and many other plastic laminated products—and we will continue to do so as long as we are able—to help war-essential civilian activities to continue here at home.

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FORMICA

Topics

BOMBING at night requires perfect dark-adaptation of the aviator's eyes. Under this condition the eye is particularly sensitive to blue, especially over the outer boundaries of the retina. Red, on the other hand, is seen only over a relatively small area of vision and is thus difficult to detect. As a matter of fact, while yellow and orange have highest visibility to a light-adapted eye, in darkness the brightest region of the spectrum is blue and blue-green, according to the Color Research Laboratory of the Eagle Printing Ink Co.

♦

INDIA possesses all the prerequisites for attaining a leading position in the production of aluminum. Rich deposits of bauxite are found in five provinces and a great amount of low-grade bauxite suitable for an alumina cement in other parts. At present, the Aluminium Co. of India, Ltd., is the only plant in India producing aluminum. It has a fully equipped sheet mill and plans to erect an additional reduction plant soon.

♦

ELIMINATING the procedure that all orders bear end-use symbols, Priorities Regulation No. 10, should facilitate production of war supplies. Authorizations for manufacture of military and essential items are now tailored for the first time to fit the known supplies of materials. WPB's copper branch as well as iron and steel branch requirements of General Preference order M-17 and M-21 are not affected by the revocation of Regulation No. 10.

♦

DRAWINGS and specifications of foreign-owned patent applications seized by the office of War Information will be printed and made available to American industry at a nominal price. These applications ordinarily cover latest developments in patentable fields and many can improve American processes and devices.

♦

CREATION of a federal "department of planning" to enable America to make the best use of technological advances in the postwar period has been suggested by Roy C. Muir, General Electric. Underlying philosophy of the agency must be to remove, rather than to place, obstacles in the path of technological progress. According to Mr. Muir, "If we are to obtain and maintain a long-range plan to which we may work, we must have some of the ablest men in the country devoting their lives to this task. In the past, the engineer has been too willing to limit himself to the technological part of his task, leaving the social and economic aspects to others."

♦

EIGHTEEN tons of scarce metals will be saved in the manufacture of General Electric's war products this year through the use of a new manganese nonmagnetic alloy. The savings include ten tons of nickel, seven of chromium and one of tin.

♦

SIX-BLADED propeller, three rotating each way, with electric pitch control, has been developed by Curtiss-Wright. During the past few years manufacturers have been developing dual rotation propellers, the associated problems of which are tremendous. These include sufficient spacing, axially, to prevent turbulence. This introduces critical torsional problems and the difficulty of matching the performances of each set of blades when the front one is driven by a relatively long, flexible solid shaft and the other by a shorter, large diameter, stiff hollow shaft.

♦

WITH respect to shortened V-belt life resulting from too-high tension, an increase of three pounds per inch per ply over the recommended tension results in the belt giving only approximately one-third of its useful service life.

♦

RECOGNIZING the importance of the South American markets, particularly now when hemisphere solidarity is vital, *New Equipment Digest* will be published in both Spanish and Portuguese for distribution to firms engaged in mining, construction, public utilities, transportation, processing and manufacturing. A tabloid size review of latest industrial developments, equipment, processes, materials, methods and applications, this new Latin-American publication will be called *Revista Industrial*.

Redesign Speeds Gun Production*

By John L. Miller

Chief Metallurgist, Gun Mount Div.
The Firestone Tire & Rubber Co.

REDESIGN for improved performance and faster production of a 40 mm. antiaircraft gun carriage is typical of the part American industry is playing to assure final victory in this world-wide conflict. Of the type of the Swedish Bofors automatic antiaircraft cannon, the redesigned gun utilizes welded fabrication in effecting the improvements. These also include increased accuracy and stability

*From the Second Grand Award paper in a contest sponsored by James F. Lincoln Arc Welding Foundation, Cleveland.

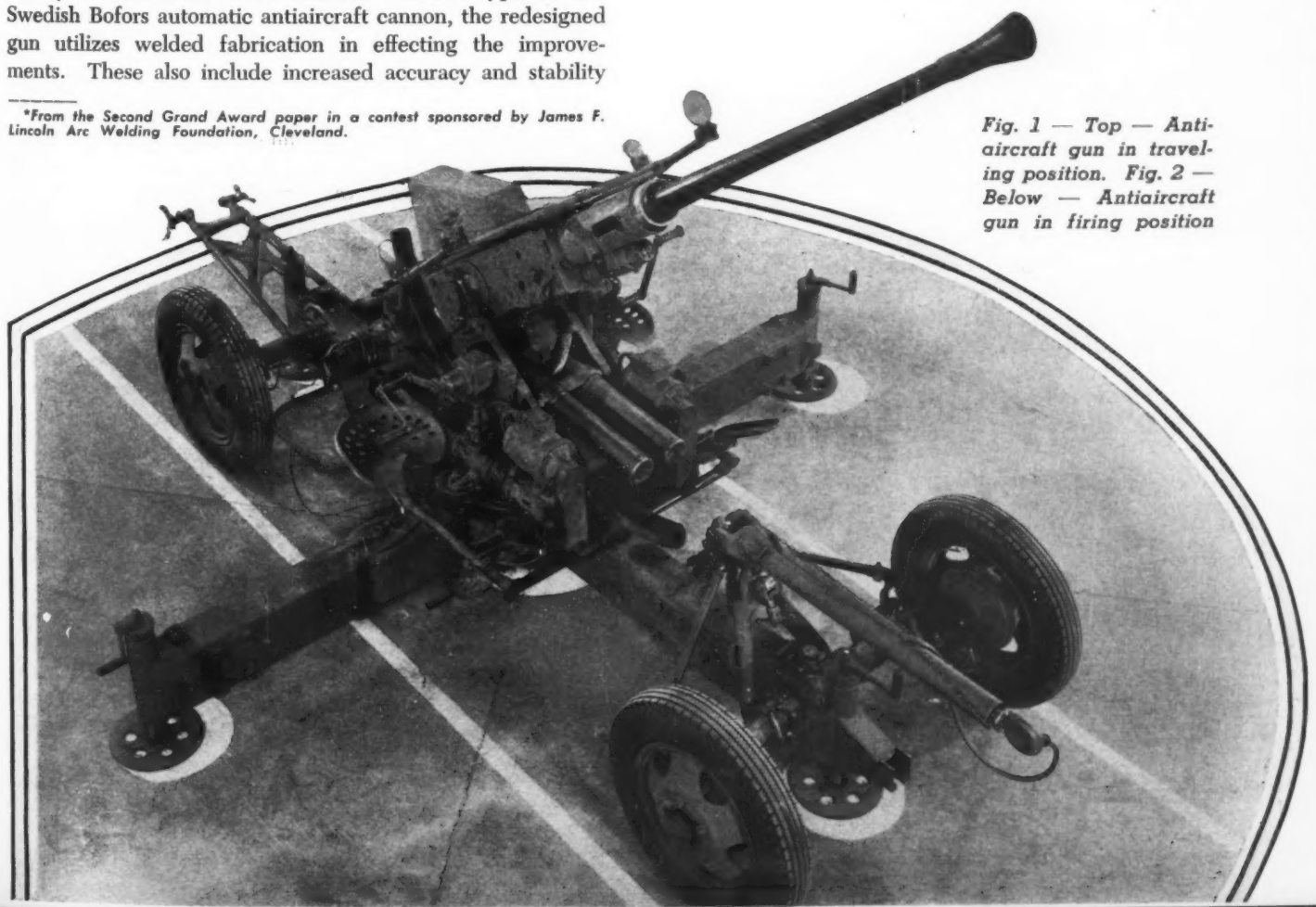


Fig. 1 — Top — Antiaircraft gun in traveling position. Fig. 2 — Below — Antiaircraft gun in firing position

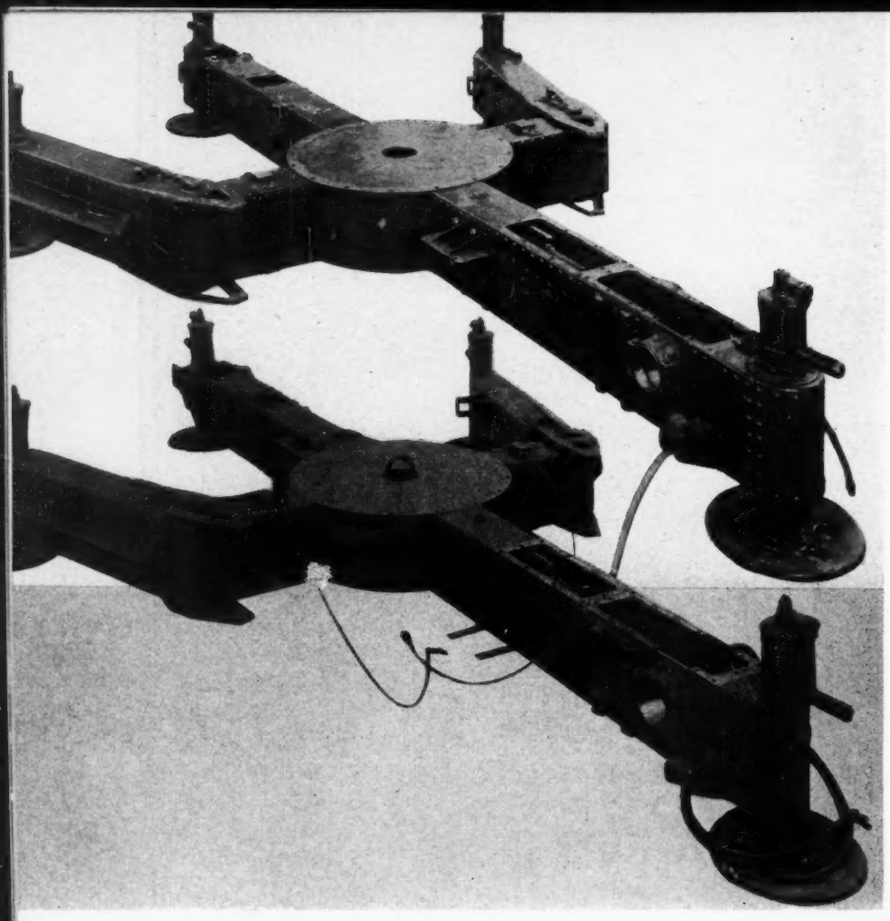


Fig. 3—Riveted chassis sent from England compared with redesigned chassis utilizing welded fabrication

in traveling and in firing as well as reduced costs.

Value of an intermediate caliber, automatic cannon for defense of vital supply centers and for defense of field troops against operations of low-flying aircraft was demonstrated by the Civil War in Spain. During that period, the 40 mm. Bofors gun proved its efficiency and reliability. Since then this gun has been widely adopted, particularly by the British and now by the American forces. The decision was based on reports from, and personal observations in, combatant countries and as a result of exhaustive tests.

Provides for Rapid Maneuverability

The gun is mounted on a top carriage attached to a cross bed chassis having lateral outriggers, *Figs.* 1 and 2. This chassis is mounted on four wheels equipped with 6.00 x 20 transport tires having bullet resisting tubes, all wheels utilizing electric brakes. Carriage wheel base is 126 inches and the gun may be elevated from minus 5 degrees to plus 90 degrees and may be traversed 360 degrees. The projectile has a weight of approximately 2.2 pounds and leaves the muzzle at a velocity of 2,850 feet per second.

TABLE I

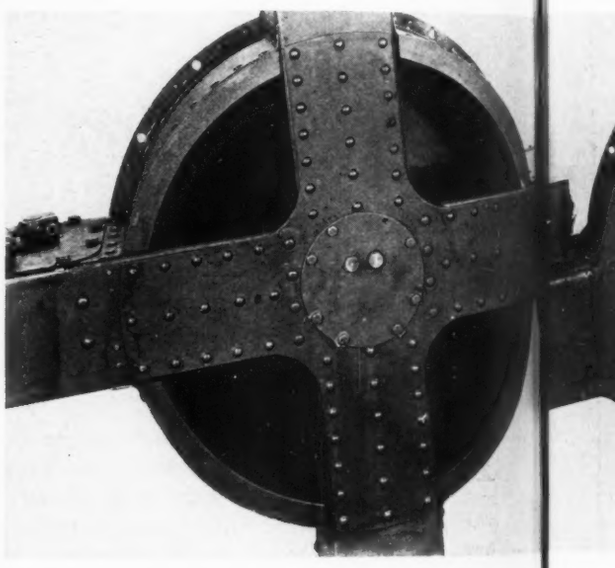
Physical Values for Plain Carbon Steel Welds on Low-Alloy, High-Strength Steel

Yield Strength (psi)	Tensile Strength (psi)	Elongation (%-Free bend)
60,960	84.020	38.0
59.590	79.540	56.0
55.580	78 900	42.0
58.160	77.790	46.0
59.910	76.930	44.2
54,440	80.100	54.0
57.000	79 030	45.2
57,440	78.860	48.0
53.570	77.620	62.0
59,050	77,850	39.5

Shots may be fired at the rate of 120 to 140 per minute, usually in bursts of 4 to 6 shells.

In view of its rapid maneuverability, the gun is adapted particularly to use against low-flying aircraft, including dive bombers. It has a maximum horizontal range of approximately 11,000 yards and a maximum vertical range of approximately 5,400 yards. The effective range is 2,500 yards horizontal or vertical.

During firing the gun carriage is supported at four points by jacks having large diameter foot plates additionally secured by four stakes driven into the ground and guided by brackets attached to the chassis. This position is shown in *Fig.* 2. Front and rear wheels are retracted during firing to eliminate vibration



which would occur if the recoil energy were transmitted to the ground through the rubber tires. This retraction is accomplished by the equilibrating action of strong springs housed within the box girder of the chassis frame. Electrical wiring for the brakes, front and rear lights and the wiring which conveys current to the motors which operate the oil gears also are housed within this girder.

Calculation and experience have shown that box type construction results in the strongest possible frame for a gun carriage of this type. The gun breech and tube are manufactured elsewhere and forwarded for assembly on the gun carriage. Total weight of the complete gun and gun carriage is approximately 6,000 pounds.

Redesign Includes U. S. Standards

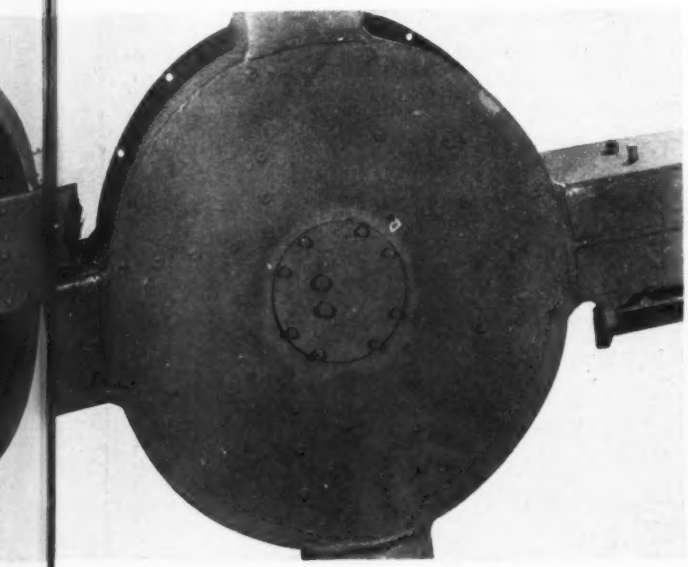
From the study of an imported mount and such drawings as were furnished, redesign was indicated. Because the drawings showed dimensions in the metric system and employed metric or first angle projections, it was required to transpose them to accord with United States Ordnance standards. This involved redrawing approximately 1,400 separate drawings and the introduction of 460 United States government standard data sheets for parts such as nuts, bolts, screws, and washers. An-

TABLE II

Physical Properties of Chassis Parts

Part	Material	Yield Strength (psi)	Tensile Strength (psi)	Elongation (% in 2 in.)	Reduction (% Area)
Spline shaft	WD 1035	65,000	81,000	16	...
Eccentric Sleeve	WD X4130	75,000	100,000	20	...
Plate top	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Jack tube	WD 1020	53,000	64,000	23	...
Backing strip	WD X1020	40,000	60,000	20	40
Jack tube plate	WD X1020	40,000	60,000	20	40
Rib support	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Side plates	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Stake brkt. guide	Steel Casting	53,000	85,000	22	35
Eccentric boss	WD X1020	40,000	60,000	20	40
End plate	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Eccentric bracket	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Bottom plate	Low-Alloy High-Str. Stl.	50,000	95,000	20	...
Cap reinforcing block	WD 1035	40,000	70,000	20	40
Stake tip	WD 1035	40,000	70,000	20	40

Fig. 4—Bottom view of riveted tub showing, at left, open design required for riveting, and redesigned tub with enclosed bottom



other important transposition involved changes of all materials used in fabrication so as to make them available within the United States.

Necessity for selecting materials adequate for the intended service but containing a minimum of alloying elements which are particularly strategic was a complicating restriction. To illustrate this, the English had made a large number of parts using steel containing appreciable quantities of nickel. The material changes almost completely eliminated nickel steels. In most cases these material changes were accomplished without reduction of the unit area physical properties by taking full advantage of processing and heat treating methods proved by modern metallurgy. A total of 1,485 individual parts are required for the gun carriage.

During this period, many design changes were proposed and approved by the Ordnance Department. Important design changes, saving millions of dollars in machine tools and in man hours involve welded construction, use of a single-ball thrust bearing instead of a double-constructed ball thrust bearing for the traversing gear, elimination of thrust bearings in the elevating gears, use of bearings produced from sintered powder metals instead of solid bronze, welded tubular axle construction instead of a forged axle, change in mounting the gun trunnions on the top carriage, employment of rubber bumpers instead of a steel spring within the draft connector, and use of four-wheel electric brakes instead of two-wheel hydraulic brakes. Of these the most important change was the use of welded instead of riveted construction. Ordnance designers had suggested that the possibility of welded construction be investigated for the chassis and top carriage. Welded designs for these parts were developed and extended to include many other components.

This redesign work was all the more remarkable in that it

Fig. 5—Front or swivel end of foreign model, shown at top, and redesigned end. Bearings are sintered powder metal. Additional nosepiece adds to strength and allows travel over rougher roads

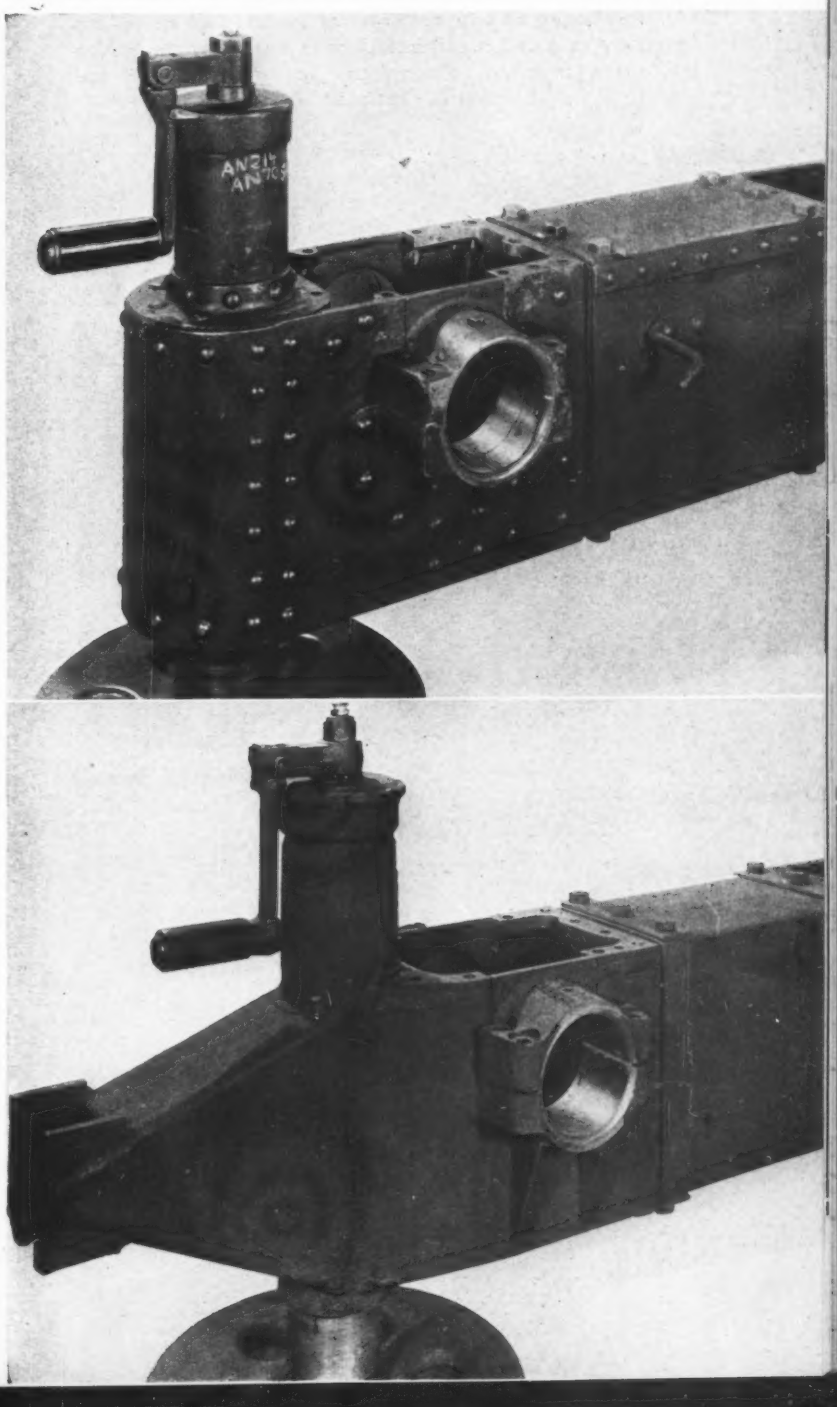


TABLE III

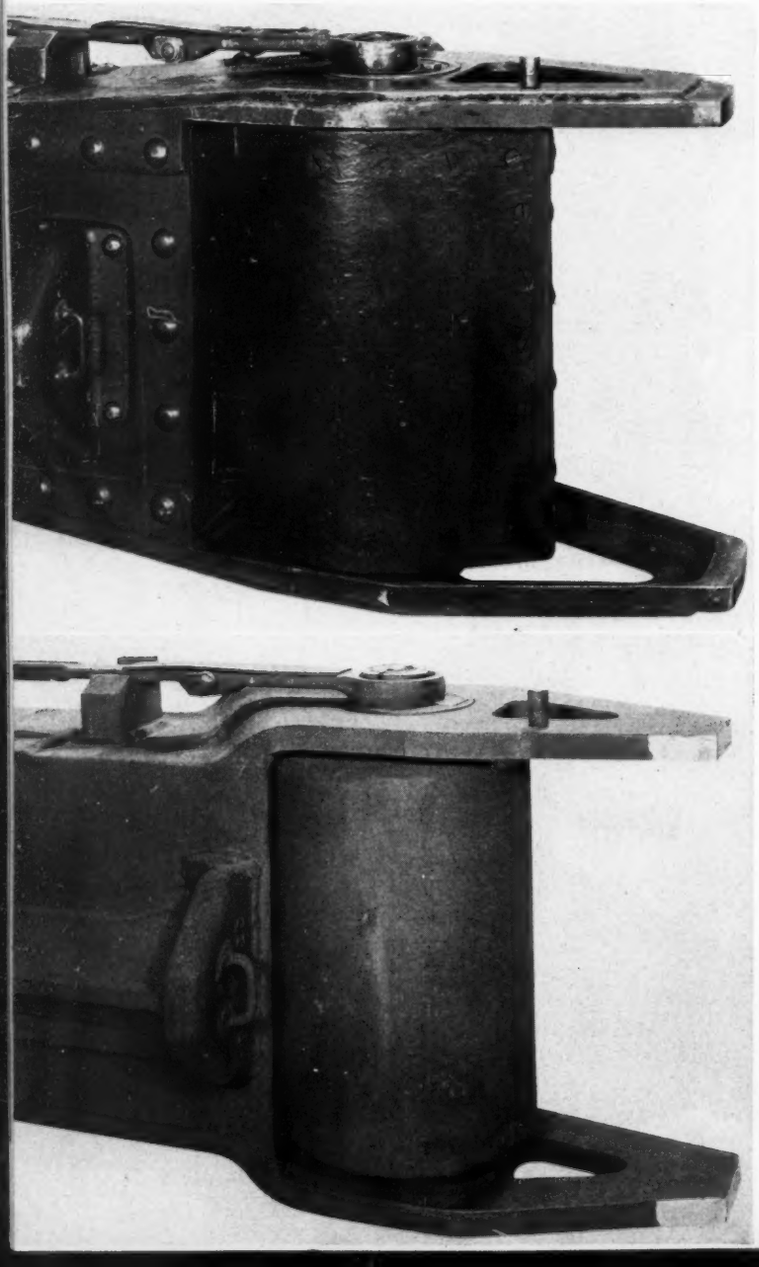
Chemical Analyses of Materials

Material	C	Mn	P Max	S Max	Cr	Other Elements
WD 1035	.30—.40	.60— .90	.045	.055	.....	.....
WD X4130	.25—.35	.40— .60	.040	.050	.80—1.10	Mo. .15—.25
Low Alloy, High Strength Steel	.10—.20	.50— .70	.040	.040	.50— .65	Si. .60—.90 Zr. .10—.20
WD 1020	.15—.25	.30— .60	.045	.055	.....	.....
WD X1020	.15—.25	.70—1.00	.045	.055	.....	.....
Steel Casting	.30 max.	1.10 max.	.050	.065	.....	Mo. .40—.65 Si. .55 max.

had to be conducted simultaneously with the transformation from the metric to the American system and with the change from foreign to American materials, with a minimum of time lost in getting into production. The weldability of each material forming part of a welded assembly was carefully considered and chemical analyses controlled to give the best welding characteristics consistent with the designing engineers' strength requirements.

To insure relief of local locked-up stresses occurring during welding and during cooling from welding temperatures, it was decided advisable to stress relieve all important weldments. Therefore, the minimum design strength of each welded material was determined in terms of its room temperature strength after exposure to a temperature of 1150 degrees Fahr. for a minimum period of one hour. Welding engineers and metallurgists will be interested in studying the chemical analyses and physical property data (TABLES I, II and III) for an appreciation of how this was accomplished. The extensive use of the new low-alloy, high-strength steels is noteworthy.

Fig. 6—Portion of one outrigger at location of swivel on foreign model, at top. Handle lock is riveted on as is also the stake bracket. Redesigned construction for the section is shown at bottom



To meet the strength requirements of the Army Ordnance department, which are more rigid than those applied to foreign designs, the plates used in the construction of the entire gun carriage are 50 per cent thicker. As the drawings for the redesigned carriage were completed, they were immediately used for the construction of parts for two experimental models. By adopting such a procedure, it was possible to have these models ready soon after the last of the drawings had been made. These pilot models were completed in June, 1941, and sent to the Aberdeen Proving Grounds for testing. Gun breeches and tubes were obtained from a Canadian source and exhaustive roadability and firing tests were conducted. These Aberdeen tests proved the general excellence of the redesigned welded carriage although slight increases in the sectional thicknesses of a few parts subsequently were made, an additional strengthening member at the front of the carriage was added, and the draft connector was made longer and heavier.

TABLE IV

Estimated and Actual Costs

Item	Estimated	Actual
Material	.....	$167.31
Labor involved in welding	$ 68.40	74.80†
Total Labor	261.60	238.20
Stress Relieving Cost	4.34	3.91
Total Cost*	433.25	409.42

† The actual welding time exceeded the estimate because of repairs made necessary by critical Ordnance inspection.
* This does not include overhead or any profit.

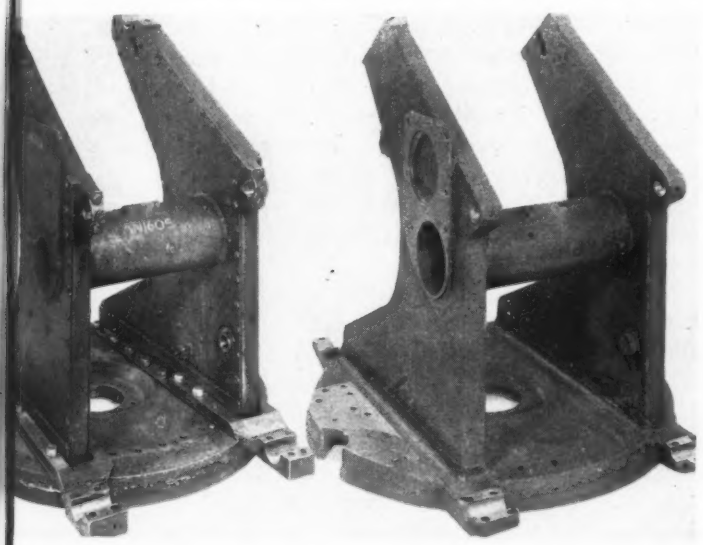
This redesigned and improved carriage is now able to travel at the highest speed of which the prime mover is capable and, within one minute, can be placed in firing position with complete assurance that firing accuracy has not been impaired. Firing accuracy is dependent as much upon the strength and precision of the carriage as of the breech and tube, because the elevating and traversing mechanisms form part of the carriage, and these must be manufactured to extremely close dimensional tolerances. Any lack of gun carriage rigidity during travel or actual firing would be translated to these mechanisms, causing over-stressing with consequent distortion. This carriage is, then, not only a means of conveyance for the gun, but an integral part of the operation of the gun itself.

Cost figures for the Bofors gun or for the English modification are not available. Because of different wage standards, such figures would be of little value even if

available. During the redesign period, detailed estimates of the expected costs of riveted and welded constructions were developed. These estimates indicated that welded construction would save considerable money and labor, and employment of welding jigs and fixtures make construction advantageous for quantity production.

Design of the carriage details is not static and in a minor way is changing from day to day, simplifications being introduced which result in increased production at less cost. Whatever the design change may be, it is necessary that each important part or subassembly be interchangeable with foreign models and with carriages produced during

Fig. 7—Foreign model of top carriage, left, employing riveted and bolted construction. Greater strength at reduced cost has been obtained in the redesign



other stages of manufacture. This is such an important consideration that many desired changes must be sacrificed.

Frame structures of the original Bofors gun and of the English adaptation are riveted. This includes as major items the chassis, the top carriage, and the elevating gear segment. Over 1,000 rivets are required to complete such assemblies. This discussion is devoted to the advantages of welded design in comparison with the riveted construction employed by foreign manufacturers. In view of the necessity for obtaining greater strength for better roadability, the American carriage is, therefore, necessarily heavier than the English or Bofors constructions. To obtain a comparable picture of the weight advantages accruing as a result of the employment of welded rather than riveted construction, the data as presented will show the actual weight of the American model subassembly, the weight of the corresponding English riveted subassembly, and finally what this weight would be if riveted construction were used and if the section thicknesses were the same

Fig. 8—Riveted compared with welded redesign for elevating arc sector

as employed in the American model. This weight comparison is summarized in TABLE VIII, Page 180.

As indicated in *Fig.* 3, this chassis is of the box girder type, having two outriggers. The steel in the chassis is low-alloy, high-strength type, Federal Specification 57-114-1, Class B, Grade 2. This specification limits the chemical analysis to a maximum carbon content of .25 percent, leaving additions of other elements unrestricted. It imposes a physical property limitation of 50,000 pounds per square inch minimum yield strength, 95,000 pounds per square inch maximum tensile strength and 20 percent in two inches minimum elongation.

Plates forming the box sections are 3/16-inch thick and the plates forming the tub or central section are ½-inch and 3/16-inch thick. All the subassemblies are positioned for welding, plain carbon steel, covered electrodes, 5/32-inch diameter being used. Experiments indicated that the use of an alloy electrode was not required to obtain strength equal or superior to the strength requirements for the rolled, forged or cast sections being joined. No special preparation of the joints is necessary and a low-carbon steel back-up strip is employed. Sixty-six pounds of 5/32-inch diameter electrodes are required for the complete welding of the chassis of the gun as finally redesigned.

In TABLE I are shown typical physical properties se-

TABLE V

Physical Properties of Top Carriage Parts

Part	Material	Yield Strength (psi)	Tensile Strength (psi)	Elongation (% in 2 in.)	Reduction (% Area)
Turntable	Low-Alloy High-Str. Stl.	50,000	95,000	20	
Side plates	Low-Alloy High-Str. Stl.	50,000	95,000	20	
Base bearing	WD 1020	40,000	60,000	20	40
Brackets	WD 1020	40,000	60,000	20	40
Spacers	WD 1020	40,000	60,000	20	40
Bearing	WD 1020	40,000	60,000	20	40
Boss	WD 1020	40,000	60,000	20	40
Clip	Low-Alloy High-Str. Stl.	50,000	95,000	20	
Bushing	WD 1035	65,000	81,000	16	
Spacers	Low-Alloy High-Str. Stl.	50,000	95,000	20	
Body tube	Low-Alloy High-Str. Stl.	50,000	95,000	20	
Stop	WD 1020	40,000	60,000	20	40

TABLE VI

Material and Labor Costs for Top Carriage

Part	Riveted Construction (Estimated Costs) Material	Labor	Total	Welded Construction (Actual Costs) Material	Labor	Total
Turntable	$55.00	$ 6.94	$ 61.94	$47.00	$ 6.94	$ 53.94
Side Frame Parts	9.99	9.12	19.11	9.20	6.45	15.65
Side Frame Parts	9.98	9.16	19.14	9.19	6.49	15.68
Side Frame Assembly	.39	3.34	3.73	.22	3.53	3.75
Side Frame	.39	3.34	3.73	.22	3.28	3.50
Top Carriage Assembly	.64	1.44	2.08	.45	6.39	6.84
Top Carriage Machining	.38	14.94	15.32	.38	14.94	15.32
Body Tube Assembly	2.12	3.48	5.60	2.12	3.48	5.60
Totals			$130.65			$120.28

cured on experimental test plates, which had been stress relieved at a temperature of 1150 degrees Fahr.

Welding methods used in attaching brackets, stake supports, outrigger locks, and other parts to the chassis

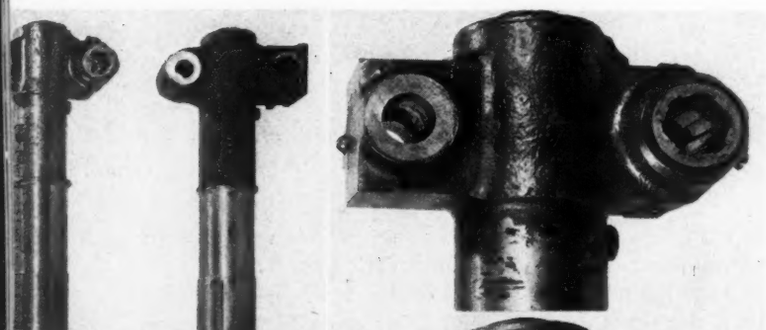


Fig. 9—Typical axle made abroad compared with redesigned one. Details of head construction are compared in right-hand view

frame, should be compared with the procedure employed in fastening corresponding parts on the foreign model. *Fig.* 4 contrasts the designs employed in forming the bottom section of the drum or central section. Comparative top construction is shown in *Fig.* 3. The foreign design does not completely cover the bottom of the tub. Obviously this would be impossible because of the necessity for getting on the inside to rivet. A double plate is required to secure the needed strength. The welded design consists of a single plate which completely covers the tub bottom, thus adding needed strength without the necessity of an additional plate. *Fig.* 5 shows the construction employed at the front or swivel end of the foreign model. Aside from the riveted construction, a needlessly expensive method of securing the bearing surface for the axle tube was used. The redesigned model employs sintered powder metal bearings for the axle tube. The simplified lines and the increased rigidity made possible by the use of arc welding is apparent. *Fig.* 6 indicates the improvement effected in the outrigger hinge.

Exhaustive deflection tests to determine rigidity of the chassis in comparison with the imported model were made to check the redesign calculations and the unit strength of the metals and welds in the new chassis. One such test will be described:

Two chassis, one the English riveted model, and the other our welded chassis, were placed on a level concrete floor in traveling position as indicated in *Fig.* 1. Six dial indicators graduated in thousandths of an inch were mounted on separate supports under the central or tub section and positioned in a circle at 60 degrees intervals. A 3,000 pound weight, which was a static overload of 75 percent, was placed on top of the central or tub section and the deflection noted on each of the six dial indicators. This test was repeated several times with the following average results: Riveted chassis, .079-inch deflection; welded chassis, .051-inch deflection. The difference of .028-inch in favor of the welded chassis corresponds to 55 percent greater rigidity for the welded chassis.

Both types of chassis returned to their original positions when the loads were removed, indicating that the stress was completely elastic and that the load was not sufficient to produce plastic or permanent deformation. Other similar deflection tests on the front, rear, left and right ends gave corresponding results, all of which were later confirmed by road tests at the Aberdeen Proving Grounds.

Functions as an Integral Unit

Weight of the riveted chassis is 824 pounds and that of the welded chassis without the steering support is 1,071 pounds. The weight difference of 247 pounds or 30 per cent, combined with the welded design has produced this 55 per cent increase. The increase in rigidity resulting from the use of welded construction is therefore 25 per cent. This additional strength is due to the fact that the welded chassis functions as an integral unit under stress. The nose piece, shown in *Fig.* 5 adds greatly to the strength of the front end of the carriage as it forms a rigid support for the steering mechanism. This addition, which greatly improves the road performance of the American redesigned model, is not present on the foreign model.

To insure weldability of all brackets, supports and locks attached to the chassis, the chemical analysis of

(Continued on Page 174)

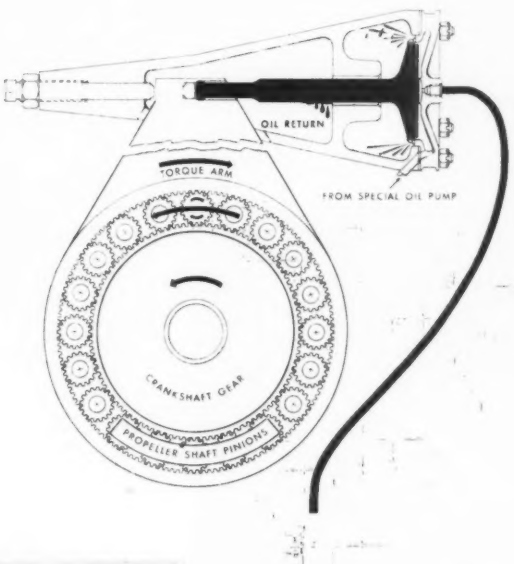
TABLE VII

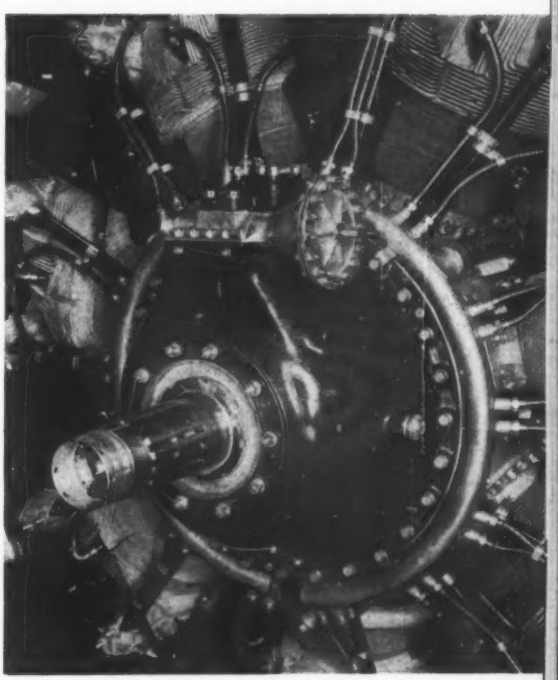
Physical Properties of Elevating Gear Parts

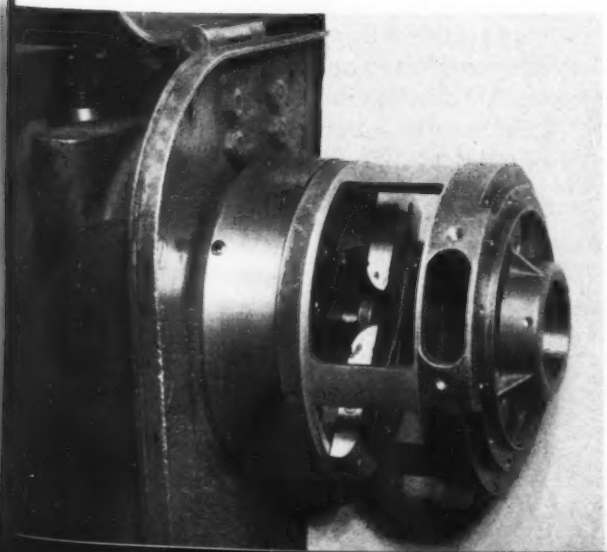
Part	Material	Yield Strength (psi)	Tensile Strength (psi)	Elongation (% in 2 in.)	Reduction (% Area)
Base	WD 1035	55,000	70,000	20	40
Gear segment	WD X4130	75 000	100,000	20	40
Stop	WD X4130	75,000	100,000	20	40
Side plates	Low-Alloy High Str. Stl.	50,000	95,000	20	40
Spacers	WD 1020	40,000	60,000	20	40
Shim	WD 1020	40,000	60,000	20	40

Scanning the field for IDEAS

Precision engine control in the interest of maximum operating economy is facilitated by the use of torque indicating instruments as shown in the photograph and schematic drawing at right. Developed by Wright Aeronautic Corp., the instrument has its torque arm splined to a sun-gear arrangement as shown. This torque arm engages at its outboard end a torque balancing piston which is in reality a pressure-relief valve for the oil pump and as such permits the oil pressure in the chamber to build up to the value required to produce a total piston force exactly equal to the torque reaction load on the end of the torque arm. Because the oil pressure is proportional to the engine torque, it can be indicated by an ordinary pressure gage calibrated to the engine and instrument characteristics. Since the load on the valve is derived from the stationary reduction gear torque reaction, the oil pressure is at all times proportional to the engine torque and can be calibrated to read brake mean effective pressure. From this and engine speed, horsepower may be computed.



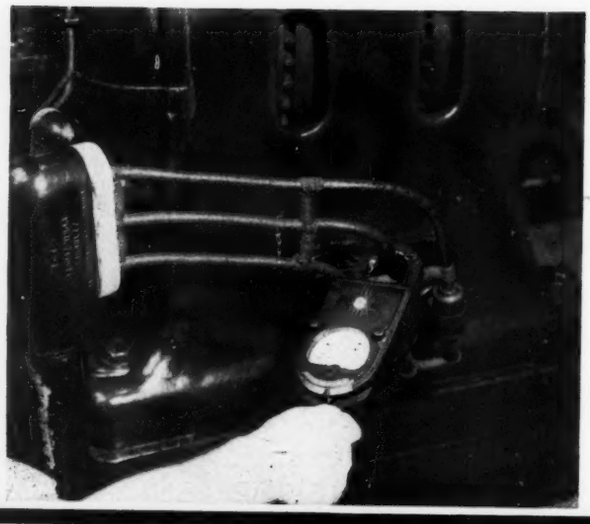




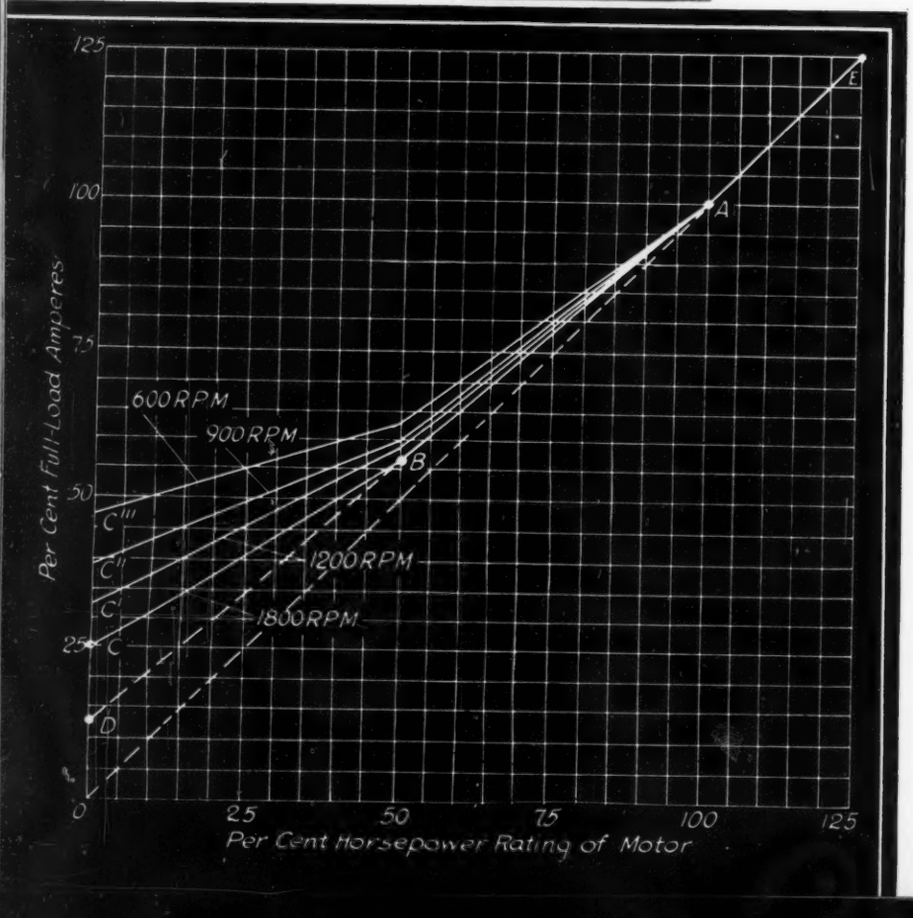
Automatic clamp utilizes the inertia of a handwheel to supply the force necessary for tightening as shown in the illustration at left applied to a faceplate for production machining of brackets. Centrifugal force, caused by spindle rotation, positions two clamps. Inertia of the handwheel attached to a rod passing through the spindle tightens the clamp by means of a lefthand threaded nut. This carries the rod forward against the inside of the clamps which are hinged on links. A button mounted on the end of the rod applies the pressure against the clamps. Thrust between the rod and button is taken by a steel ball. A garter spring is hooked to the two clamps with sufficient tension to hold the clamps

to the center of the faceplate to facilitate loading. Developed by Westinghouse, the arrangement shown is suitable for clamping from inside on openings or ledges.

Special bearings where required in limited lots are economically produced with sprayed metal to give the exact characteristics desired. Four such bearings are shown at left, made by Metallizing Engineering Co. Inc., each lined with approximately .020-inch of high-grade babbitt. One is backed with magnesium, one with aluminum, one with bronze and one with stainless steel. Babbitt and metal are sprayed on a mandrel to the required thickness, outside machined and then pressed off the mandrel to give a bushing having the proper bore without further machining. Porosity is controllable to give desired self-lubricating qualities as well as required strength. Tests to determine resistance to compressive stresses encountered when assembling in an arbor press showed 78,850, 53,100 and 30,600 pounds per square inch for stainless, aluminum and bronze, respectively.



Loading on motors can be determined quickly by the use of a hook-on ammeter as shown at left when instruments are not included in the system for this specific purpose. Today when overloading rather than underloading is recommended to save vitally needed power and materials that would otherwise be wasted through low efficiency and low power factor, it is especially helpful to have a convenient method of estimating loads. From the nameplate data and the ammeter reading it is possible to determine the per cent of horsepower rating direct from the accompanying chart prepared by the General Electric Co. If this curve is not available, one may be prepared simply for a given motor. Point A represents full-load current at horsepower rating, both taken from nameplate data; C is no-load current; D is midway between O and C; B is midpoint of AD; AE is extension of AO. Then curve CBAE is the current-horsepower curve. This method and the acompanying chart are applicable to motors of integral horsepower ratings up to 100.



From one half to full load, it can be seen that the motor current is roughly proportional to horsepower output because both efficiency and power factor are higher and more nearly constant. Above full load, the current continues to increase in direct proportion up to 125 per cent of full load. This can be useful as a guide in carrying out wartime recommendations on increased motor loadings.

Accuracy of this method of construction of a horsepower chart is said to be within two per cent up to full-load rating of the motor.

Wartime Metallurgy Conserves Strategic Materials

Part V—Hardenability

By R. E. Orton and W. F. Carter
Acme Steel Co., Chicago

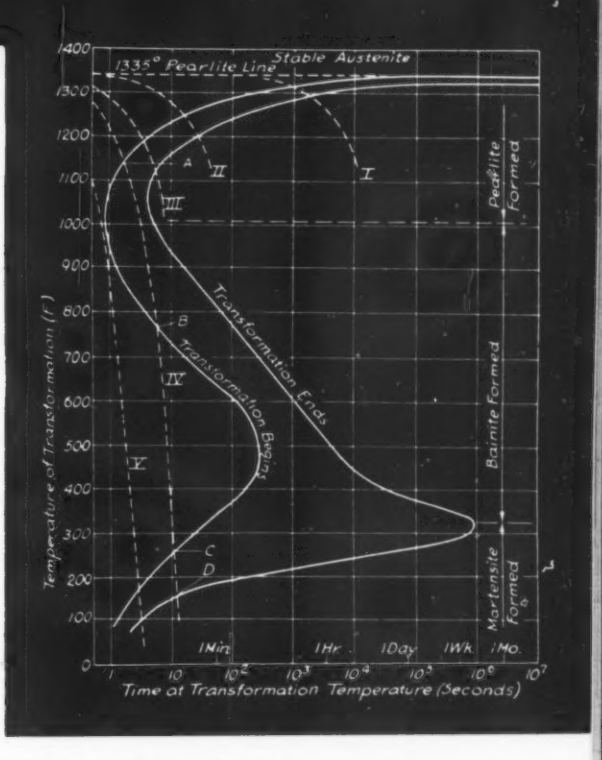


Fig. 36—Above—Transformation of carbon eutectoid steel at various cooling rates. Curve I, furnace cooling; Curve II, air cooling at center of 1-inch diameter; Curve III, oil quench at center of 1-inch diameter; Curve IV, water quench at center of 1-inch diameter; Curve V, water quench of 3/8-inch diameter

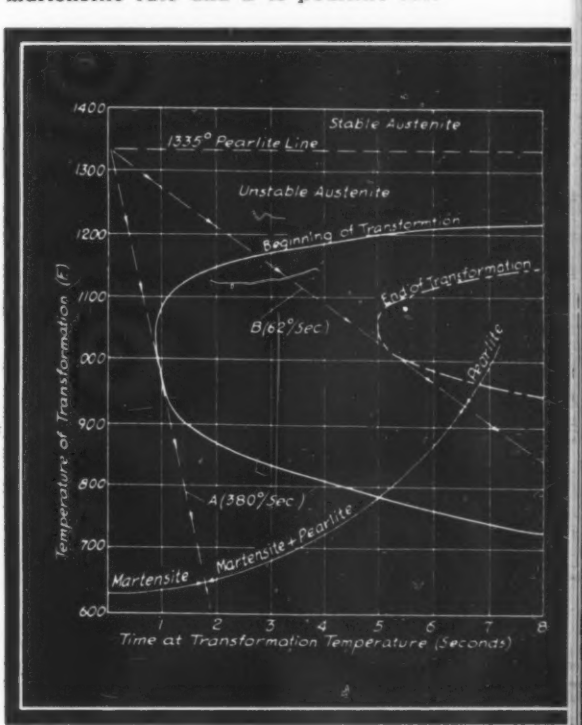


Fig. 37—Below—Critical cooling rates for carbon eutectoid steel. Line A is martensitic rate and B is pearlitic rate

WHILE it has been realized for many years that steels differ in the "ease" of their hardening, it is only recently that many of the factors affecting this "ease" have been recognized. Also, tests affording a quantitative measure of this quality have only recently been developed.

Alloying additions are made to steels primarily to improve hardenability for the purpose of securing greater depth of hardness or to permit the use of a milder quench. As is so often the case with new developments, appreciation of the gain in interior hardness obtained by the addition of alloys has been followed by overemphasis on the deficiency in this respect of carbon and low alloy steels. This has frequently led to the specification of a far higher alloy content than genuinely needed by the particular application. In a time of national emergency when all alloys must be classed as either strategic or critical, such reckless extravagance can ill be afforded. Since requirements such as these emanate in the main from the design engineer, it is of paramount importance that he realize the implication of his specifications so that he will more critically examine the need.

Hardenability is measured by the ease of obtaining a fully martensitic structure. This concept is qualitative. To obtain a quantitative concept it is necessary to consider the fundamental characteristic of which the above may be construed as the result rather than the cause. This may be done by examining further the isothermal transformation curves, investigation of which was begun in the preceding article.* Since quenching is the usual method of commercial hardening, the discussion will begin by examining, in the light of these curves, the result of transformation at varying cooling rates.

Transformation of carbon eutectoid steel at various cooling rates is illustrated in *Fig.* 36. The solid curves give the time to initiate and complete the tranasformation of austenite at constant temperatures. Theoretically, these are obtained by instantaneously lowering a specimen to

*MACHINE DESIGN, November, 1942.

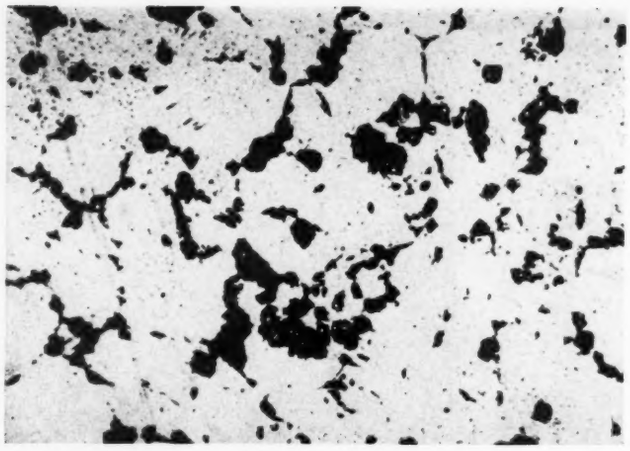


Fig. 38—Mixed martensite and emulsified pearlite, characteristic of intermediate cooling rates. Carbon eutectoid steel. 500 diameters

the transformation temperature and then holding at that temperature while observing the reaction time. The short time transformation region or gate occurs near 1000 degrees, the long completion region or toe near 300 degrees. Transformation above the gate yields the various pearlites; between the gate and the toe, bainite; below the toe the fully hardened constituent, martensite.

The dotted curves across the isothermal curves indicate various cooling rates: Curve I—the slow rate of furnace cooling with the formation of coarse pearlite; Curve II—the air cooling of small sections, with the production of a finer pearlite structure; Curve III—the intermediate cooling rate which produces emulsified pearlite. Increase in the cooling rate beyond this value to that of Curve V causes the upper portion of the curve to be missed completely, transformation occurring below the toe with the formation of martensite.

Curve IV, intermediate in speed between that of III and V, yields a mixed structure. At *A* the formation of emulsified pearlite begins. Before it can be completed the temperature has fallen to *B*, thereby retaining the austenite remaining at this temperature down to *C*, at which point the transformation to martensite begins, being completed at *D*.

Now, if by "hardenability" is meant the obtaining of a fully martensitic structure, the measure of this ability is the ease with which the quench can get the steel past the gate of the isothermal curve. Obviously, any quench passing the gate will proceed without difficulty to the toe, assuming that the temperature of the quenching medium is reasonably well below the toe temperature.

Ease of passing through the gate will depend upon the width of the gate and its location with regard to the region of austenitic stability. If it be assumed that quenching mediums cool at a uniform rate within this temperature range, (which is admittedly not quite the case), a quantitatitve value may be set upon hardenability by saying that it is measured by the slope of a straight line drawn from zero time and "just stable" austenite, to tangency with the transformation curve near its gate. The use of this concept involves the plotting of time to regular coordinates, as illustrated in *Fig.* 37.

To correlate this data with that of quenching rates the slope will be expressed in terms of required cooling rate, the so-called "critical cooling rate". Higher rates will then indicate lower hardenability, and the reverse. The hardenability value for this carbon eutectoid steel is then 380 degrees per second. This value may also be approximated directly from *Fig.* 36 by dividing the distance in degrees from the pearlitic line to the gate of the curve, by the width of the gate in seconds.

Consideration of these curves brings forth the concept of a second hardenability value, that cooling rate which is sufficient to bring the steel past the gate of the curve of completion. Cooling rates less than this yield wholly pearlitic structures. While such rates will still give some increase in hardness due to the formation of finer pearlite, compared with the hardness of martensite such structures may be described as "not hardened". Thus, three structural zones are marked out by these cooling rates. Portions cooling faster than the high rate, fully hardened martensite; regions cooling slower than the slow rate, unhardened pearlite; in between, a partially hardened zone of mixed pearlite and martensite.

The first of these critical cooling rates will be referred to as the "martensitic" rate, and the second the "pearlitic" rate. "Critical rate" alone refers to the martensitic rate.

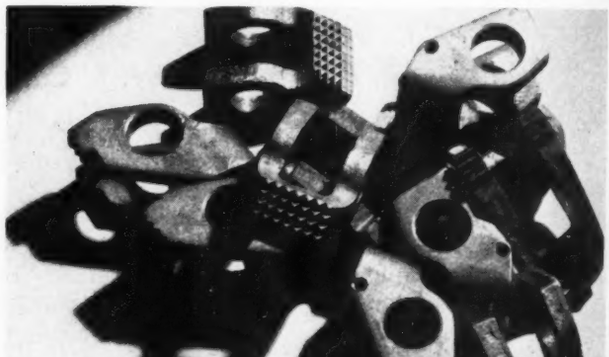
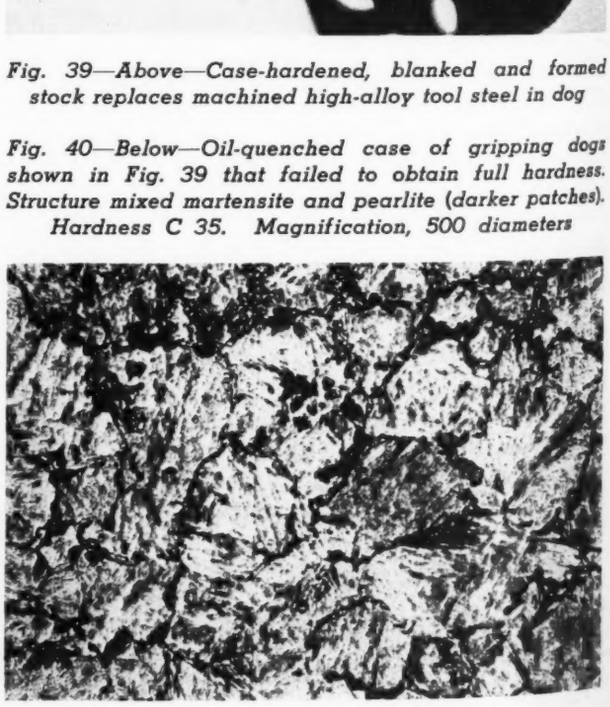


Fig. 39—Above—Case-hardened, blanked and formed stock replaces machined high-alloy tool steel in dog

Fig. 40—Below—Oil-quenched case of gripping dogs shown in Fig. 39 that failed to obtain full hardness. Structure mixed martensite and pearlite (darker patches). Hardness C 35. Magnification, 500 diameters



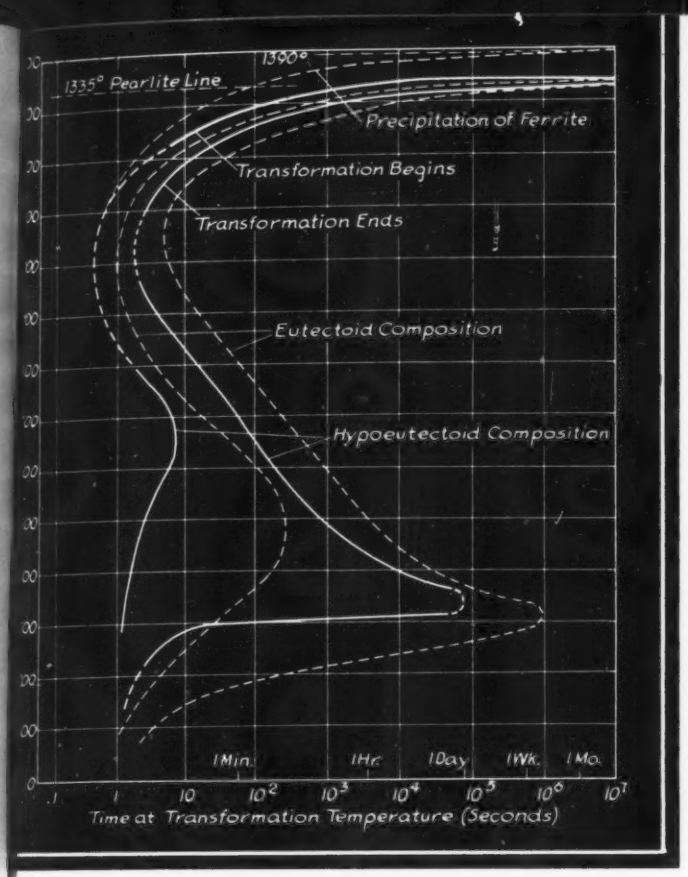


Fig. 41—Isothermal transformation curves for .54 per cent carbon steel. Dotted portions of these curves are estimated (from Davenport)

This carbon eutectoid steel has a pearlitic rate of 62 degrees per second.

To illustrate these three zones a carbon eutectoid steel specimen, 2 inches in diameter by 6 inches long, was quenched in water from 1450 degrees. *Fig.* 42 is a hardness traverse taken along a diameter of the mid cross section. *Fig.* 38 is a photomicrograph characteristic of the mixed structure of the transition zone.

This, together with the discussion in the previous article, will make it apparent that the hardness obtained in a quenching operation is a function of three variables:

1. The capacity of the steel for hardness
2. The hardenability
3. The rate of cooling.

The capacity of a steel for hardness is dependent primarily upon the carbon content. *Fig.* 32 in the previous article gives the values that may be obtained from a given carbon content. The hardenability determines the cooling rate necessary to obtain martensite, the hardest form of steel for a given carbon content. This cooling rate may be obtained from the isothermal transformation curve, or by experimental methods to be described later. The cooling rate at any portion of a piece is dependent upon the quenching process and the dimension of the part. This will be discussed in a later article.

Previous considerations have been of the isothermal curves of eutectoid steel. What is the effect of varying the steel composition? Unquestionably, the primary effect of any alloy addition is in altering the position and the shape of the transformation curves. The fundamental effect of these alterations is in the change in hardenability.

Transformation curves for a .54 per cent carbon steel are shown in *Fig.* 41, with the eutectoid composition lightly dotted in for comparison. Data for the solid portions of the curves are taken from Davenport[1]. The curves have been shifted bodily to the left, greatly narrowing the gate for both initiation and completion, decreasing thereby the hardenability. The cooling rate for martensite has increased to 1000 degrees per second, 2½ times that for the eutectoid steel, a rate which may only be found near the surface of a water-quenched steel. The pearlitic rate has increased to 200 degrees per second, over three times that of the eutectoid. Full hardness in this steel may not be expected throughout any but the very smallest section.

As the equilibrium diagram of *Fig.* 25† shows, hypoeutectoid steels precipitate the excess ferrite on slow cooling. *Fig.* 41 indicates that this tendency persists with even faster cooling rates. Unless the rate exceeds the critical value, portion of the excess ferrite is precipitated.

The mixed structure of ferrite, pearlite and martensite, resulting from cooling rates somewhat less than the critical, is more the rule than the exception in hypoeutectoid carbon and low-alloy steels. While it is true that, if the quantity of these softer constituents is not large, the effect on the hardness is small, McQuaid[2] and others feel that the structure is objectionable from the standpoint of fatigue and brittleness. There is a good deal to be said for this viewpoint; yet it should be borne in mind that it has not been proved.

Reduction in hardenability with lowering of the carbon content is strikingly brought out in the heat treating failure of the "gripping dogs" shown in *Fig.* 39. In a strapping machine, these dogs hold one end of a steel band while strapping it around a package. Parts were originally high-alloy tool steel. In the interest of war economy a change has been made to a low-carbon, stamped and formed blank into which the teeth are milled. The part is hardened in carburizing salts by increasing the surface carbon content to the eutectoid composition, then quenching in oil, followed by a low draw. The light section, 5/32-inch thick, hardens satisfactorily in oil due to the increased hardenability resulting from the increased carbon content. Use of a water quench would result in excessive warpage. Application for over a year has proved the substitution successful, the indication even

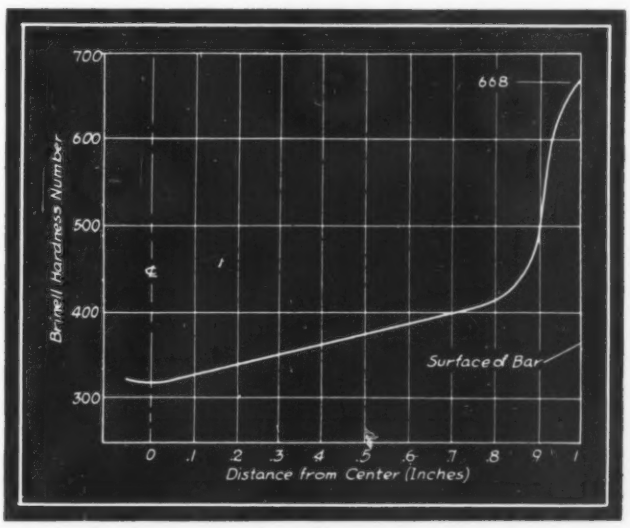


Fig. 42—As-quenched hardness traverse across a 2-inch diameter carbon eutectoid steel bar. From center to .8-inch, pearlite; from .8 to about .94-inch, mixed structure; from .94 to surface, martensite

[1] All numbered references are listed at end of article.
†Machine Design, October, 1942, Page 72.

being of an improved life over the high-alloy steel.

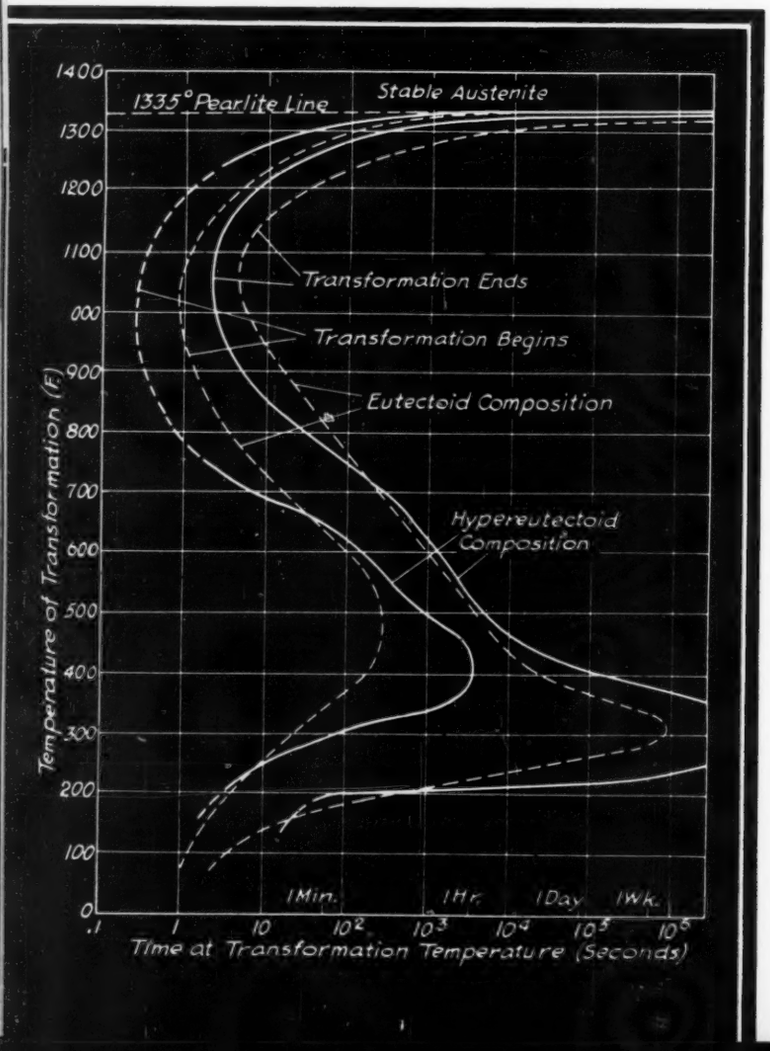
However, trouble was experienced with one batch of parts which failed to harden to the expected limits, about rockwell *C* 35 being obtained instead of 63 to 66. Check on fractured sample showed usual case depth. As a first experimental approach to the problem, one of the dogs was reheated to the austenitizing temperature and quenched in water. Hardness was increased to about *C* 55, still below the expected level. From these results the conclusion was warranted that the hardenability had been reduced well below the expected level; further, either the critical cooling rate lay still higher than that obtained in the water quench, or else there was a lack of full capacity for hardness. *Fig.* 40 is a micro of the oil-quenched case. Structure is martensitic with grain boundaries outlined by pearlite, a definite indication of an intermediate cooling rate. Examination under the microscope of the water quenched structure showed full martensite—the critical cooling rate had been exceeded. Manifestly, the capacity for hardness did not exist.

With the preceding discussion in mind it is apparent that full hardenability and capacity for hardness had not been attained due to a low-carbon content in the case. This was confirmed by a metallographic analysis for carbon. Slowly cooling to a pearlitic structure and estimating the pearlite content showed only about .35 per cent. Examination of the salt content showed contamination.

Transformation curves for a hypereutectoid steel, from Davenport[1], are shown in *Fig.* 43. It might be expected that the trend toward slower transformation rates with increasing carbon content would be continued; but instead the trend is reversed. At the gate this steel actually transforms in less time than that required for the .54 per cent carbon steel. The critical rate is 1450 degrees per second; the pearlitic rate 170 degrees per second.

It is probable that there is also a carbide line, similar to the ferritic line of *Fig.* 41. The uncertainness of this is due to the sluggishness of solution of the excess carbides. *Fig.* 44 is a photomicrograph illustrative of the above. This 1 per cent carbon steel, originally spheroidized, was held at the austenitizing temperature only long enough to pick up a portion of the carbide. The quenching rate was then such as to cross partly into the transformation zone on the way down to the martensitic transformation temperature. The light portion is martensite, the dark patches pearlite. Sprinkled throughout may be seen the remnants of the spheroidized carbide.

Fig. 43—Isothermal transformation curves for 1.13 per cent carbon steel. Dotted portions of these curves are estimated (from Davenport)



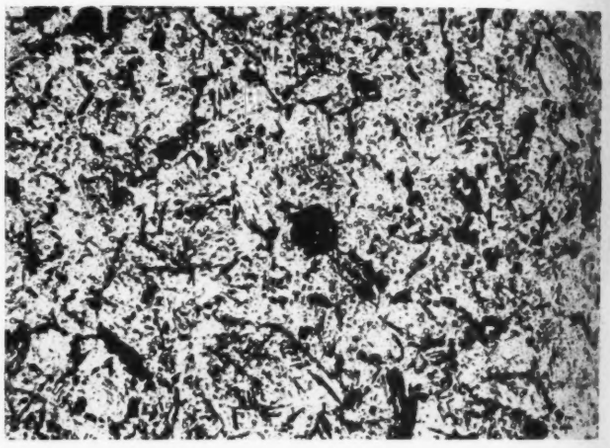


Fig. 44—Mixed structure of martensite, pearlite and spheroidized carbide due to insufficient holding at austenitizing temperature and an intermediate cooling rate. 1 per cent carbon steel. 500 diameters

While the isothermal transformation curves give the most hardenability information, the labor of collecting the data to construct them is enormous. They are therefore used only to indicate trends due to changes in the analysis or other characteristics. Some simpler method is needed for analysis and production control. Of the different methods that have been proposed, the recently introduced "Jominy end quench"[3, 4] is the most widely accepted.

In Jominy's test a specimen bar of the steel under investigation is heated to the austenitizing temperature and quenched by a jet of water played against its end. The austenitizing temperature, time at temperature, dimensions of the bar, jet size, force and temperature are all standardized. A hardness traverse is then taken along the bar length. The hardenability is expressed as the distance from the water-cooled end at which the drop in hardness is considered to indicate departure from a fully martensitic structure.

Cooling rates along the bar are plotted in *Fig.* 45‡. Knowing, from the test, the distance at which a martensitic structure is not obtained, *Fig.* 45 gives the critical cooling rate. The variation in the quenching rate with the temperature at which it is measured introduces a com-

‡The equation of this curve is $R = 11.5d^{-1.38}$, for $.038 < d < 2.5$, where R = cooling rate in degrees Fahr. per second at 1300 degree and d = distance in inches from water-cooled end.

plication in correlating the rate as thus obtained with that from the isothermal curve. This will be discussed in more detail in a later article.

The Jominy test affords a direct comparison, with fair reliability, between different steels[5, 6]. It seems probable that this test will eventually become an important speci-

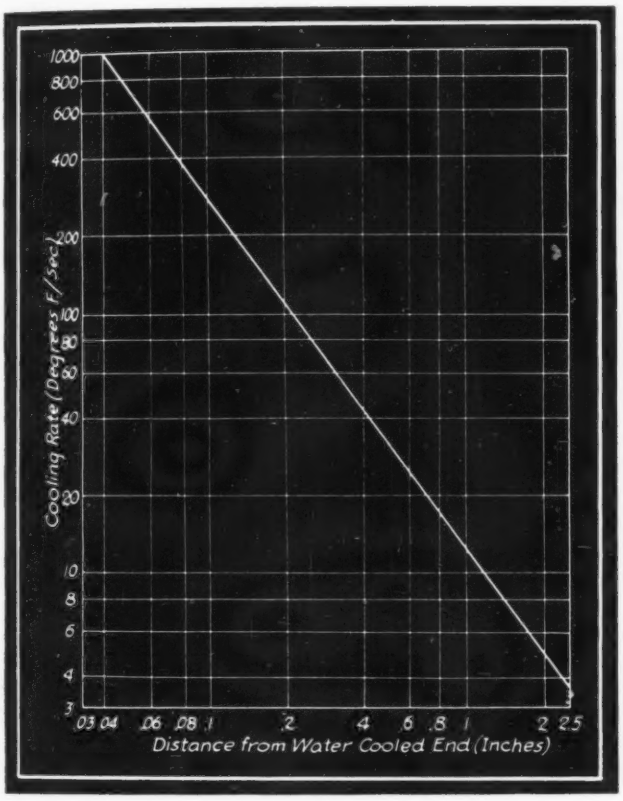


Fig. 45—Cooling rate, at 1300 degrees Fahr. along Jominy end-quench hardenability bar

fication requirement. With the specification of this test it would appear feasible to relax the tolerances for analysis, requiring only that the steel be of the analysis type desired, and meet a Jominy value. Adoption of such a practice should materially increase steel production and reduce production costs.

It has been stated that the hardness obtained at any interior portion is a function of the capacity for hardness, the hardenability, and the cooling rate. Capacity is fixed by the carbon content. Cooling rate is fixed by the quenching practice, shape of the part, and location of the portion in the part. The hardenability must then be adjusted to obtain the desired hardness. Specification for surface hardness is nearly always justified. The same cannot always be said of the specification of interior hardness. The practice has grown up of asking for far more than is genuinely required. This results in a needless wastage of alloys to obtain a required hardenability.

Frequently, the application is such that the requirements of interior hardness may be much less than at the surface. In the case of a shaft under pure torsion the stress varies directly as the distance from the center. Supposing that the bar used in the hardness traverse of *Fig.* 42 is to be employed on such an application, and that the strength varies directly as the brinell hardness, then, if

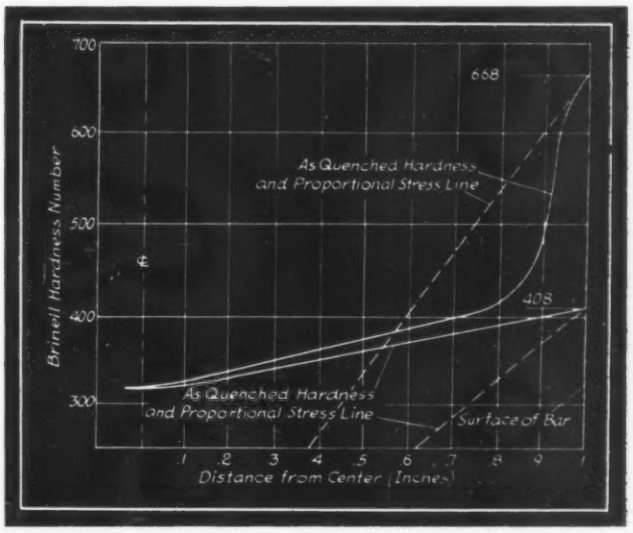


Fig. 46—As-quenched and as-tempered hardness traverses across a 2-inch diameter carbon eutectoid steel bar. The first lies below its proportional stress line, the second above its proportional stress line

the part were to be used without tempering, the full strength being required at the outside, the hardness at all interior points would be required to lie above the "proportional stress line" shown dotted in *Fig.* 46. This it does not, and therefore a deeper hardening steel, that is, one of higher hardenability, would justifiably be required.

Steel is rarely used in the "as quenched" condition. It is entirely too brittle. If the stresses are high it should be tempered to a more suitable structure. If an application requires a hardness of 400 brinell at the surface, tempering to this hardness gives the second traverse in *Fig.* 46. As would be expected, the hardness of the softer constituents is little affected by the tempering operation, so that the hardness is well above the line of proportionality. The steel *is* suitable for this application! Consideration should be always given to the hardness traverse in the *tempered* condition in which the steel is to be used.

The above is a somewhat oversimplified picture of the application of a steel to a part. There are many other factors to take into account such as variations in hardenability, permissible severity of quench, and warpage.

The next article will discuss the effect of grain size on the various properties of hardened steel, and in particular on the hardenability. This will be followed in a later discussion with consideration of the quenching and other heat treating operations.

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Malleable Iron Fills Wartime Needs

By Colin Carmichael

EFFECTIVE use of national production capacity for war requires adjustments to keep supply and demand in reasonable balance. Malleable iron castings are contributing toward restoration of this balance by relieving forging and steel casting capacity, as well as by substituting for materials such as aluminum, zinc and bronze which must be carefully conserved for special war needs. At the same time stoppage of civilian automobile manufacture, which formerly used about half the total malleable iron output, has made available the capacity to meet all anticipated demands.

Those properties, especially shock resistance, which led to such widespread use of malleable for automotive and railroad service make it a natural choice for similar applications in army vehicles, thus absorbing some of the capacity for production released by the discontinuance of passenger car manufacture. However, output of malleable can probably be stepped up at least forty per cent above current production rates, provided new applications carry sufficiently high priority.

The ordnance department is aware of the potentialities of this material and some conversion to malleable has already been accomplished. A recent example is the Bofors gun, *Fig.* 1, which now uses malleable iron for a number of castings, such as gear cases and adapters, in place of bronze and other materials. A group of these parts is shown in *Fig.* 2.

Of considerable interest also is the machine gun mount shown in *Fig.* 3. A malleable casting, this part has the light weight necessary for portability, together with the toughness needed to withstand the shocks of firing and of rough handling while changing position over rough terrain.

Combining the advantages of a casting, such as possibilities of intricate shape and minimum machining requirements, with high ductility and shock resistance, malleable iron is produced under controlled conditions to the desired specifications. Two types most widely used are the ASTM grades 32510 and 35018, specifications for which are listed in TABLE I.

It will be noted that strength and ductility both change in the same direction in going from one grade to the other, although the increase is greatest in per cent elongation. The 35018 grade is therefore the one most often used interchangeably with cast steel. However, it is found that notched impact strength and other properties are nearly the same for both grades while, due to its slightly higher

Fig. 1 — Bofors gun uses malleable castings for gear cases and adapters. Photo, courtesy The Firestone Tire & Rubber Co.

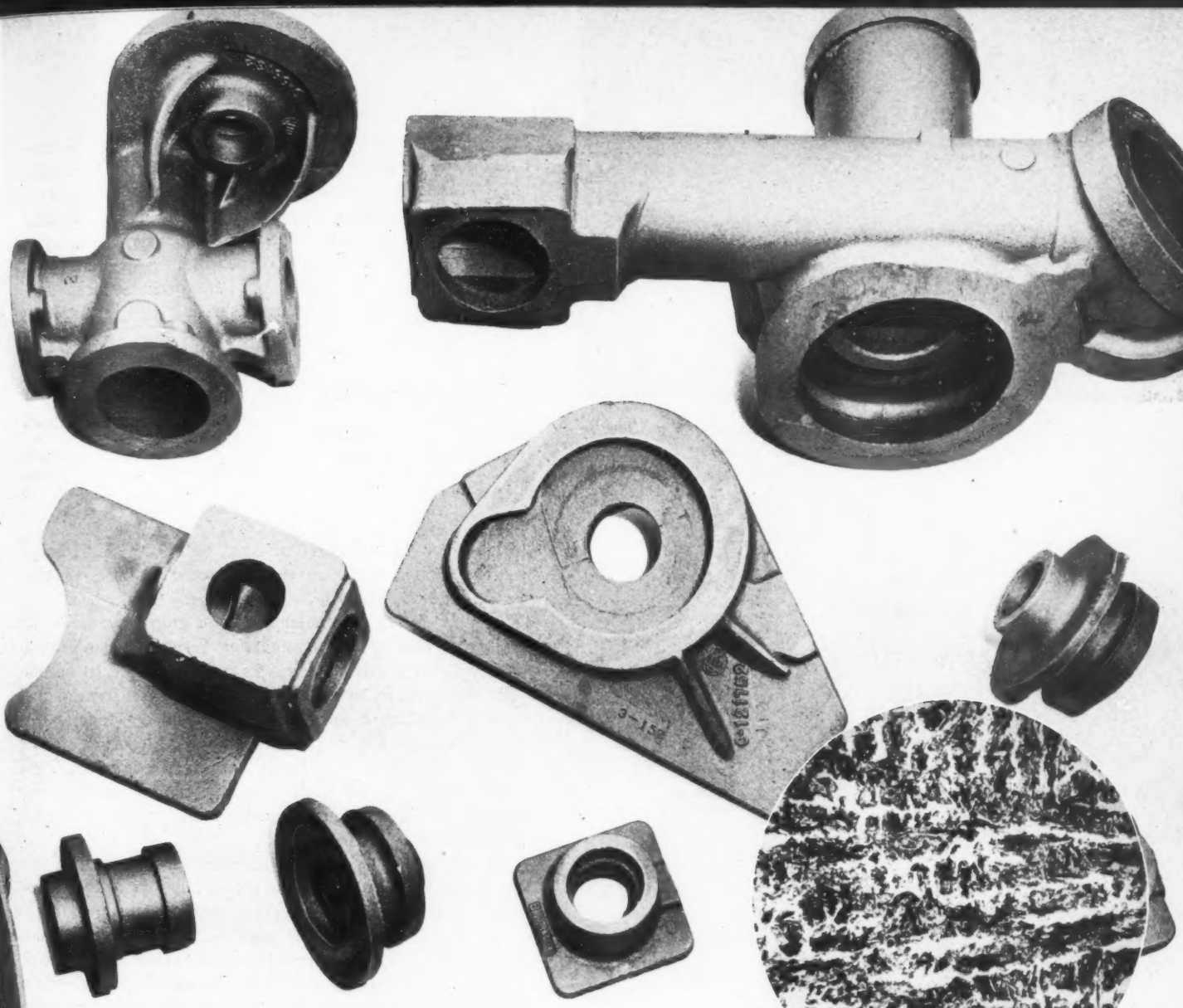


Fig. 2—Malleable castings which replace critical materials on the Bofors gun. Fig. 3 Left—In this pintle casting for a machine gun, thin sections of great toughness were obtained with malleable iron

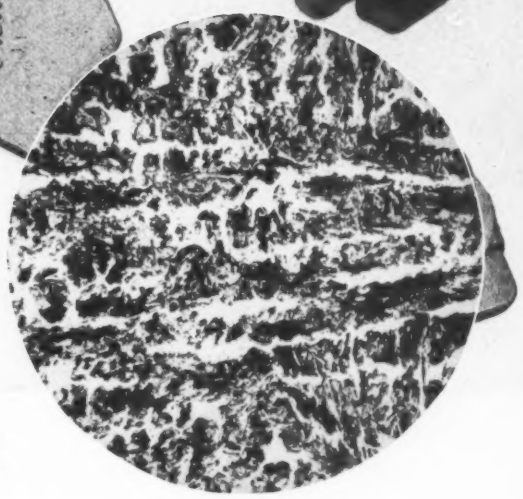
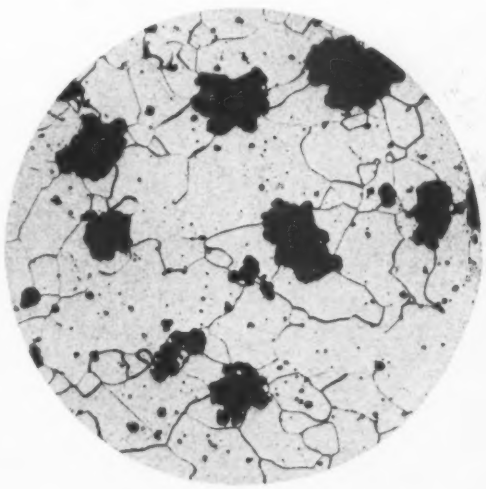


Fig. 4—Microstructure of hard, white iron casting shows pearlite (dark) and carbide. 100 diameters

Fig. 5 — Malleablized structure shows temper carbon (black) and ferrite (light). 100 diameters



carbon content, the 32510 grade is more easily cast in thin sections and, of course, machines very readily. It should be pointed out also that the physical properties in the specification are minimum, and actual castings nominally of 32510 grade frequently show strength and elongation close to the values specified for 35018 grade. The two grades are therefore quite widely used interchangeably. The range of properties which can be obtained with commercial malleable is shown in TABLE II.

Although malleable iron is used primarily for its shock resistance, no values of impact strength have been included in TABLE II because the conventional impact tests are seldom performed. Instead a special test is widely used in which a standard wedge of the material is subjected to repeated hammer blows on the point, parallel to the length of the wedge. The end curls over with each blow, and will generally sustain twenty or thirty such blows before fracture occurs. The test is a severe one and also serves to demonstrate the deformation which the material withstands before fracture.

Impact strength is maintained even at very low temperatures, malleable experiencing less reduction in this respect than does steel. This property naturally interests designers of fighting equipment which may be used in widely different climates.

First step in the production of a malleable iron casting is the making of a hard white iron casting in which all the carbon (about 1.7 to 2.7 per cent) is

Fig. 6—Steel casting (left) was redesigned for malleable (right), eliminating dry sand core in base

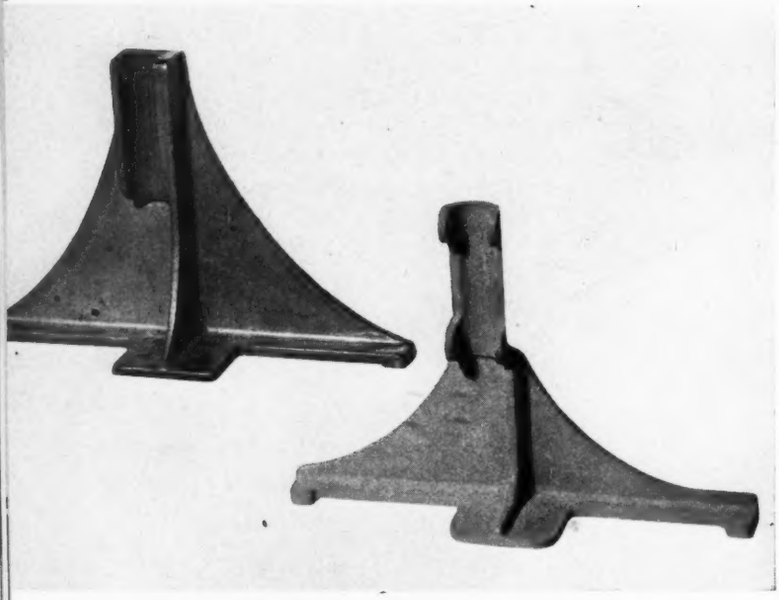


Fig. 7—Aluminum is conserved for war needs by replacing casting shown at left by malleable (right)

Fig. 8—Ball and socket joint illustrates design which takes advantage of the ductility of malleable iron

combined as iron carbide. This is accomplished by controlling the composition so as to keep the carbon and silicon contents low, the effect being to prevent precipitation of carbon as primary graphite on solidification. Typical microstructure of white iron, *Fig.* 4, shows white areas of iron carbide and dark areas of pearlite. Appearance of a fracture is actually white, but the pearlite looks dark when seen through a microscope with a vertical illumina-

TABLE I
Malleable Iron Specifications

ASTM Grade	32510	35018	Cupola
Federal Spec. QQ-I-666, Type	*B*	*A*	.....
Tensile strength, min (psi)	50,000	53,000	40,000
Yield strength, min (psi)	32,500	35,000	30,000
Elong. min (per cent in 2 in.)	10	18	5

tor because of reflection of light out of the microscope by the etched surface (see MACHINE DESIGN, October 1942, Page 69, *Fig.* 18).

Second step is the malleablizing or graphitization of the hard iron casting in an annealing furnace. The annealing cycle lasts several days, its purpose being to decompose the carbide, precipitating carbon in the form of uniformly distributed small nodules known as "temper carbon", shown in *Fig.* 5. The ferrite which forms the matrix of the structure is practically carbon-free iron combined with silicon, having high ductility and toughness. The temper carbon promotes machinability while interfering only slightly with the strength.

While a certain amount of decarburizing occurs near the surface during annealing, this is incidental, the desired effect being the conversion of hard white into tough malleable iron without change in total carbon content. Malleablizing is therefore not a surface effect and occurs regardless of the thickness of the material, while machining which removes some of the decarburized surface metal does not impair the quality of the casting.

Designing a casting for malleable iron involves only slight departure from normal practice. Because malleable is usually specified for its shock resistance, the full benefit of this property can only be realized with a design that avoids abrupt changes of section, sharp corners, stress concentrations, etc. Also because of slightly lower fluidity, provision for feeding metal to the various parts of the mold may require some thickening of certain sections. However, in conversion designs from bronze to malleable the

TABLE II
Properties of Malleable Iron

Specific gravity	7.20-7.45
Shrinkage (in. per ft.)	$\frac{1}{8}$
Coefficient of thermal expansion (per °F)	6.6×10^{-6}
Specific heat (68F to 212F)	.122
Tensile strength (psi)	50,000-60,000
Yield strength (psi)	32,500-40,000
Elongation (per cent in 2 in.)	10-25
Modulus of elasticity (psi)	25,000,000
Modulus of rupture in torsion (psi)	58,000
Brinell hardness number	110-145
Fatigue endurance limit (psi)	25,000-26,500

slight increase in metal involves no weight increase because of the lower density of malleable.

Contraction of the solidifying metal is comparatively great because there is no precipitation of carbon during

(*Continued on Page* 186)

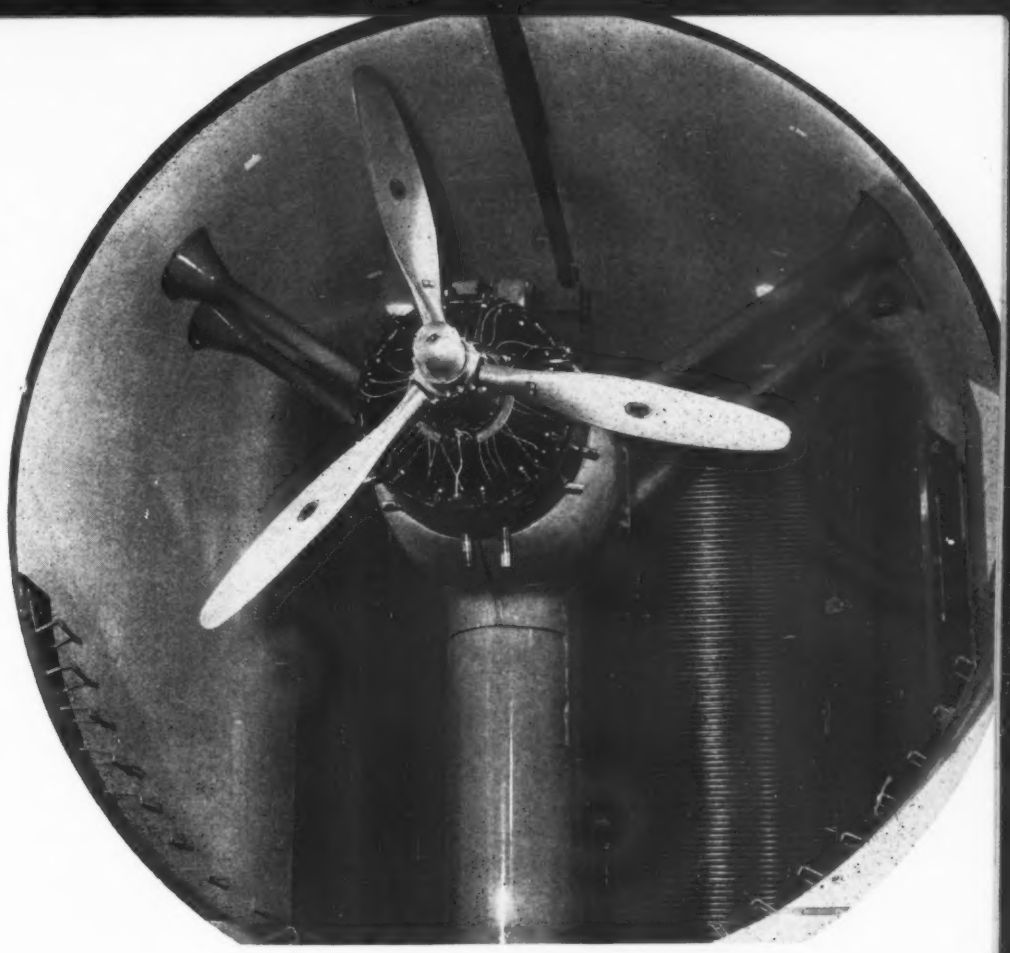


Fig. 7 — Fatigue stress analyses are vital in the design of aircraft parts. Photo, courtesy Buick Motors Div.

Part II—Fatigue Stresses

Code for Working Stresses Facilitates Design

By Joseph Marin

Pennsylvania State College

THERE are many considerations involved in the determination of equivalent static strength used to represent a fluctuating stress condition. The formulation of these strength values requires information on the static strength, defined by S_{yp} or S_u, and the endurance limit of the material for complete reversal of axial stress, designated S_e.

The following design code will consider both brittle and ductile materials as well as combined stresses. Allowance for stress concentration will also be provided, since this is an extremely important condition in fatigue loadings.

Before the foregoing strength conditions are formulated, the designer should be cautioned first against indiscriminate application of the design charts and formulas presented. When the difference between the actual loading conditions and the materials test data—upon which the code is based—becomes appreciable, then the factor N_2 providing for this difference should be modified. One important situation which is often encountered, but not always provided for, is the difference between the number of stress reversals during the expected life of a machine part and the number of reversals used in determining the endurance limit S_e.

This difference results in an overdesign but can be corrected either by modifying the factor N_2 or selecting a greater value for S_e based on the stress-cycle curve. This suggestion is not new as it has been used in the design of many machine parts. Perhaps the best known examples are ball and roller bearings whose strengths are listed in

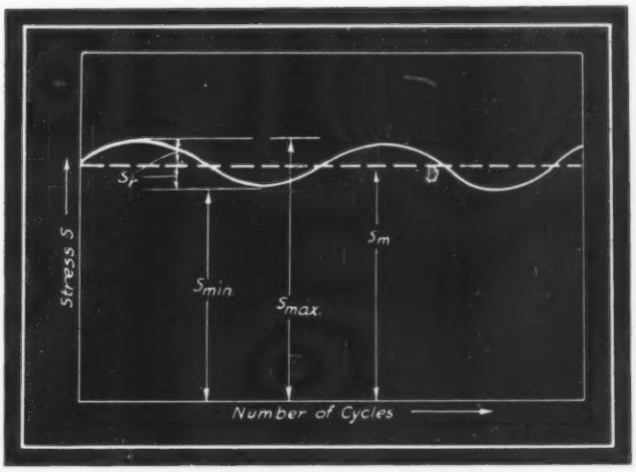


Fig. 8—Variations of stress with time

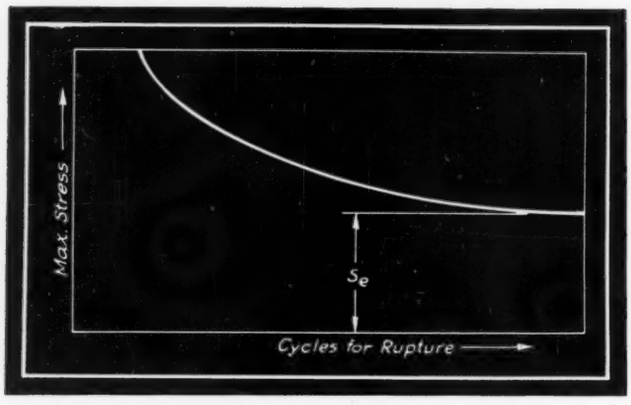


Fig. 9—Endurance limit curve

terms of particular life-time ratings.

Another difference between the laboratory test and machine part is in the manner of variation between stress and time. For example, a secondary type of fluctuating stress may be superimposed on a primary mode of stress variation due to the types of vibrations present or due to some other operating condition. This situation is encountered in such members as airplane propellers, *Fig.* 7. The fatigue strengths of materials under varying amplitudes of stress have not been determined. Further discussion of this question is given by Langer[7].

Effect of specimen size on the strength is usually more important under fatigue conditions than for static loads. Various steels, independently tested by several investigators, showed, for example, that the fatigue bending strength, S_e, of .3-inch diameter specimens is ten to fifteen per cent higher than for specimens of about 1-inch diameter[8]. The influence on the strength is also appreciable when the material is initially overstressed or understressed compared to the safe stress range[9].

Another extremely important influence on fatigue strength is the presence of stress concentration. There have been a number of investigations to determine fatigue stress concentration factors, including the effects of fillets, notches, holes and keyways. The designer should, however, be cautioned that these results apply to particular-sized specimens and that the size effect is especially important in fatigue loading conditions[10].

There are many other service conditions in machine members which differ from the laboratory fatigue test conditions[11]. A relatively new development in fatigue testing which eliminates some of the undesirable features of the small laboratory specimen is the fatigue testing of full-sized members. Fatigue tests have been reported on such parts as railway axles, riveted and welded joints, bridge rollers, beams, columns, car wheels, rails, and many other machine and structural parts[12].

In many cases it is not possible to obtain a full-sized fatigue test specimen and it is necessary to use the ordinary fatigue test data obtained on standard fatigue testing machines such as the R. R. Moore rotating beam type. If this is the situation, there is still the problem of interpreting test data and adapting it to the particular machine design problem. The formulation of the following design code, which considers effects of range of stress, stress concentration and combined stresses, appears, therefore, to be highly desirable. It should be mentioned first that many of the uncertain influences under fatigue loading mentioned in the foregoing discussion can be estimated and incorporated in the determination of the factor of safety.

[7]References are listed at end of article.

UNIAXIAL STRESSES—DUCTILE MATERIALS: For fluctuating stress the variation of stress with time in most fatigue tests is of sinusoidal form, as shown in *Fig.* 8. The stress S varies from a maximum value of S_{max} to a minimum value of S_{min}. Other stress values referred to are the mean stress S_m and the variable stress S_r. The magnitudes of these stresses in terms of the maximum and minimum stresses are:

$$S_m = \frac{S_{max} + S_{min}}{2} \qquad (j)$$

$$S_r = \frac{S_{max} - S_{min}}{2} \qquad (k)$$

The stress fluctuation can now be considered as a completely reversed stress S_r superimposed upon a static stress S_m. Then in *Fig.* 8, if $S_r = 0$, the stress is entirely static and for ductile materials failure occurs by yielding when

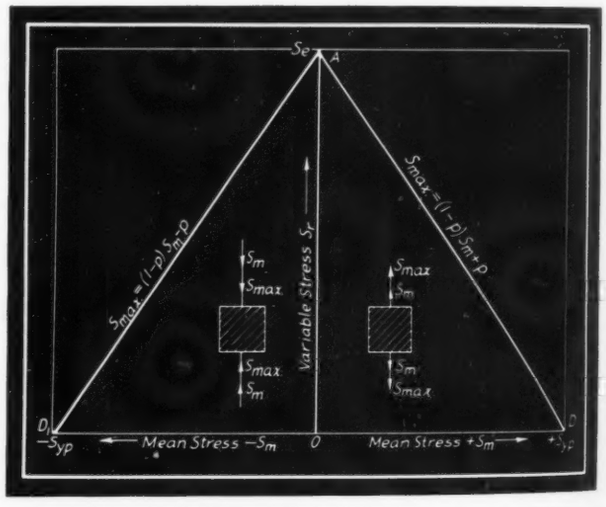


Fig. 10—Interpretation of fatigue stress data

$S_m = \pm S_{yp}$ = the yield strength for tension or compression.

When $S_m = 0$ the stress is completely reversed, as in a rotating beam specimen, and failure is considered to be the stress which will not produce fracture before the application of a specified large number of stress reversals. This stress is called the endurance or fatigue limit when the stress cycles approach a theoretical infinite number of fluctuations, *Fig.* 9. For some ductile materials such as aluminum alloys, there is no well-defined endurance strength value and a specific number of stress cycles must be used to define the fatigue strength.

Examination of test data reveals that few tests are available to show the influence of the mean stress S_m upon the fatigue strength. This is the case because an axial fatigue stress machine is required to obtain the data instead of the more commonly used and simpler rotating beam type fatigue testing machine. A review of test data available, however, shows that there are some differences in the behavior of materials when the effect of the

mean stress value is considered[13]. An approximate relationship, which is on the conservative side of the test data, is shown in *Fig.* 10. The equation for the lines *AD* or *AD'* is[14]

$$S_r = \pm S_e - pS_m \quad \ldots\ldots (13)$$

where $p = S_e/S_{yp}$.

For the purpose of evaluating working stresses it is convenient to express Equation 13 in terms of the maximum stress S_{max}. This can be done by replacing S_r by $S_{max} - S_m$ in Equation 13. This substitution gives

$$S_{max} = (1-p)S_m \pm S_e \quad \ldots\ldots (14)$$

In this way the maximum stress S_{max} producing failure is determined for a given mean stress S_m and material constants S_e and p. The influence of the mean stress on the strength by this approximation can be shown by rewritting Equation 14 as

$$\frac{S_{max}}{S_{yp}} = (1-p)\frac{S_m}{S_{yp}} \pm p$$

or

$$R_{max} = (1-p)R_m \pm p \quad \ldots\ldots (14a)$$

where

$$R_{max} = \frac{S_{max}}{S_{yp}}, \qquad R_m = \frac{S_m}{S_{yp}}$$

Variation in the fatigue strength ratio R_{max} for various values of the mean stress ratio R_m is shown in *Fig.* 11 using different possible values of the material constant p. These diagrams show that the influence of fluctuating stresses on the strength may be appreciable.

To determine working stress values for simple stresses, Equation 14 can be used provided a factor of safety is applied. When the same factor of safety N is selected for both the stresses S_{yp} and S_e then the allowable stress relationship becomes

$$S_{max} = (1-p)S_m \pm p\frac{S_{yp}}{N} \quad \ldots\ldots (14b)$$

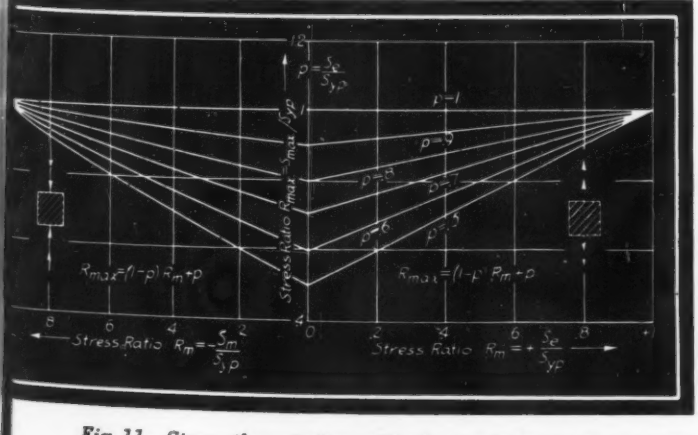


Fig. 11—Strength variation with change in mean stress ratio

When different factors of safety are used for fatigue and static stresses Equation 14 becomes

$$S_{max} = \left(1 - \frac{N_s}{N_f}p\right)S_m \pm p\frac{S_{yp}}{N_f} \quad \ldots\ldots (14c)$$

where N_s is the factor of safety for S_{yp} and N_f is the factor of safety for S_e.

Use of Equation 14*c* in place of 14*b* will depend upon the particular machine design problem. The additional uncertainties encountered with fatigue conditions will often require a larger value for N_f than for N_s.

Equations 14 have been independently suggested by several investigators in recent years, and in view of the data available they are recommended here also for most cases[14]. Some investigations show that a parabola tangent at *A* and passing through *D* and *D'*, *Fig.* 10, might be a better approximation[15]. Another modification in the test data is the difference in behavior between cases in which the mean stress is tensile or compressive[13]. Some tests show that, although Equation 14 is a good approximation for tensile mean stresses, a better approximation for compressive mean stresses is[13]

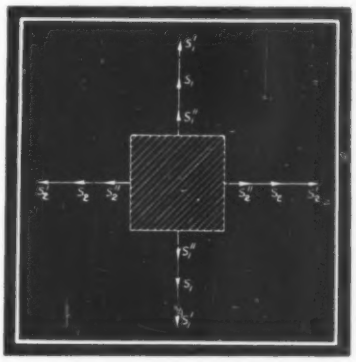


Fig. 12—Stresses on element indicating maximum and mean values of the principal stresses

$$S_{max} = S_m \pm S_e \quad \ldots\ldots (15)$$

That is, the range of stress $S_r = S_{max} - S_m$ is practically constant for all values of the mean compressive stress S_m in the tests referred to.

If stress concentration is present, a stress concentration factor K_f should be applied to the variable part of the stress[13]. Then the equation defining failure in place of Equation 14 will be

$$S_{max} = (1-p)S_m + S_r(1-K_f) \pm S_e$$

or

$$K_f S_r = \pm S_e - pS_m \quad \ldots\ldots (16)$$

The working stress relation in Equation 14c can also be modified by replacing S_{max} by $S_m + K_f S_r$. That is,

$$S_{max} = \frac{1}{K_f}\left[(1 - \frac{N_s}{N_f}p)S_m + S_r(1-K_f) \pm p\frac{S_{yp}}{N_f}\right] \quad \ldots\ldots (16a)$$

Then by Equation 16*a* the allowable value for the maximum stress S_{max}, using a mean stress S_m, is given by the right-hand side of Equation 16*a*. This stress is evaluated

in terms of the factors of safety N_s and N_f and the material constants p, S_{yp} and K_f.

The simplest method is to use Equations 14 and 16 instead of the other modifications mentioned. This is of particular importance in applying these equations to combined stresses. Furthermore, the relationships used are on the conservative side of test results and, in view of the limited information available, the use of the recommended formulas seems justified.

UNIAXIAL STRESSES—BRITTLE MATERIALS: It is generally conceded that brittle materials should be avoided, if possible, when fluctuating stresses are present in a material. When this is not possible a large factor of safety should be used and Equations 14 and 16 applied. Some data indicate that for cast iron the strength in the case of compressive mean stresses can be assumed as given by Equation 15[13]. In determining the constant p for brittle materials an equivalent yield strength can be selected as some fraction of the ultimate strength.

BIAXIAL STRESSES—DUCTILE MATERIALS: Little data are available on the behavior of either ductile or brittle materials when fluctuating combined stresses are present[16]. For a number of steels and other ductile materials subject to fluctuating torsion there is reasonable support for a distortion energy theory[14, 15]. By this theory the failure stress relation is

$$S_e=\sqrt{(S_1')^2-S_1'S_2'+(S_2')^2}-$$

$$(1-p)\sqrt{(S_1'')^2-S_1''S_2''+(S_2'')^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

where S_1' and S_2' are the maximum values of the principal stresses S_1 and S_2, and S_1'' and S_2'' are the mean values of the principal stresses S_1 and S_2. These stresses are shown in *Fig.* 12. Equation 17 is based on the assumption that the stresses are synchronous, that is, that the maximum values of the stress components occur at the same instant of time.

Similarly the mean components are assumed to occur simultaneously. Equation 17 is also based on the assumed linear strength relation given by Equation 14 for uniaxial stress. Considering S_1' as always greater than S_2', the influence of fatigue on the strength can be shown by writing Equation 17 as follows:

$$\frac{S_1'}{S_{yp}}=\frac{p}{\sqrt{1-B_1+B_1^2}-(1-p)\sqrt{A_1^2-A_1A_2B_1+A_2^2B_1^2}} \quad \ldots\ldots (17a)$$

where

$$B_1=\frac{S_2'}{S_1'}, \qquad B_2=\frac{S_2''}{S_1''}, \qquad A_1=\frac{S_1''}{S_1'}, \qquad A_2=\frac{S_2''}{S_2'}$$

Often the loads are such that the stress ratios are equal, $A_1 = A_2 = A$ and $B_1 = B_2 = B$. Then Equation 17*a* becomes

$$\frac{S_1'}{S_{yp}}=\frac{p}{\sqrt{1-B+B^2}\ [1-(1-p)A]} \quad \ldots\ldots\ldots\ldots (17b)$$

Values of the stress ratios, S_1'/S_{yp}, are plotted in *Fig.* 13 for various values of the stress ratios A and B. The ordinates to these curves give the equivalent fractional part of the simple static tensile strength represented by the combined fluctuating stresses selected. That is, a value of $S_1'/S_{yp} = .6$ indicates that the strength is equivalent to .6 times the tensile yield strength. An examination of *Fig.* 13 shows that the combined stress effect under fluctuating load conditions may influence greatly the resisting strength of the material. *Fig.* 14 represents the strength ratios for the extreme case of complete stress reversal. Equation 17*b* then becomes

$$\frac{S_1'}{S_{yp}}=\frac{p}{\sqrt{1-B+B^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17c)$$

If stress concentration is present the variable part of the stresses in Equation 17 must be multiplied by stress concentration factors. Equation 17 can then be written

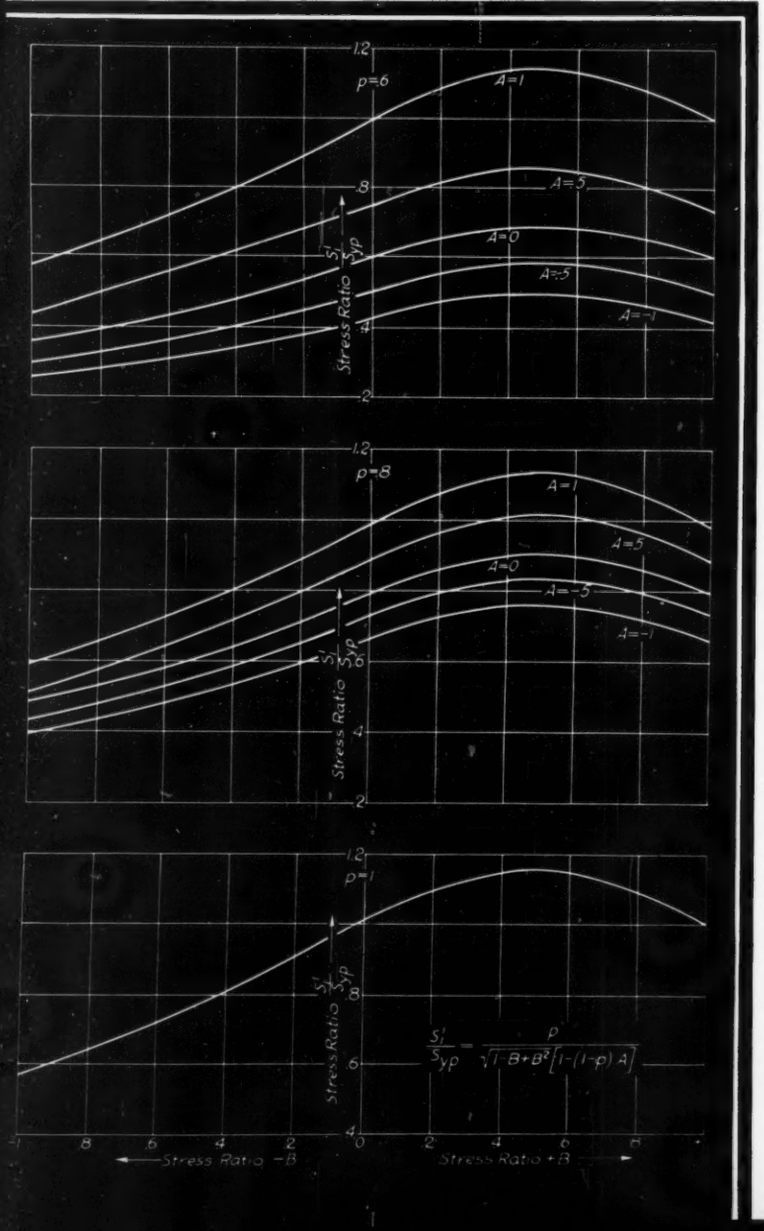
$$S_e=\sqrt{(S_1''+K_1'S_1''')^2-(S_1''+K_1'S_1''')\ (S_2''+K_2'S_2''')+}$$

$$\overline{(S_2''+K_2'S_2''')^2}-(1-p)\sqrt{(S_1'')^2-S_1''S_2''+(S_2'')^2} \quad \ldots (17d)$$

where K_1' and K_2' are the stress concentration factors and S_1'' and S_2'' are the variable stress components. That is,

$$S_1'''=S_2'-S_1'' \qquad \textit{and} \qquad S_1'''=S_2'-S_2'' \quad \ldots\ldots\ldots\ldots (l)$$

Fig. 13—Strength ratios for fluctuating biaxial stresses



BIAXIAL STRESSES—BRITTLE MATERIALS: Where it is absolutely necessary to use brittle materials under fluctuating stresses a stress theory is recommended[14]. If S_1 and S_2 are the values of the principal stresses the strength is defined by

$$\left.\begin{aligned} S_1' &= (1-p')S_1'' \pm S_e \\ S_2' &= (1-p')S_2'' \pm S_e \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

where $p' = S_e$ divided by an equivalent yield strength value in static tension. This will lead to conservative values since the static strength in compression is greater than in tension for brittle materials. If stress concentration is present the variable part of the stresses S_1 and S_2 should be multiplied by a stress concentration factor as explained above.

TRIAXIAL STRESSES—DUCTILE MATERIALS: There is no experimental data available upon which to base strength in the case of triaxial stresses. For this reason it is advisable to be conservative. A strain-energy theory[14] gives conservative strength values for triaxial stresses and is at the same time reasonably close to the distortion-energy theory in the limiting case of two-dimensional stresses. For triaxial principal stresses S_1, S_2 and S_3, the strength is defined by

$$S_e = \sqrt{(S_1')^2+(S_2')^2+(S_3')^2-2m(S_1'S_2'+S_2'S_3'+S_1'S_3')} - (1-p)\sqrt{(S_1'')^2+(S_2'')^2+(S_3'')^2} - \sqrt{2m(S_1''S_2''+S_2''S_3''+S_1''S_3'')} \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

The prime stress values represent the maximum stresses while the double prime values denote the mean stresses. When stress concentration is present each variable part of the stresses should be multiplied by a stress concentration factor, as explained for two-dimensional stresses.

TRIAXIAL STRESSES—BRITTLE MATERIALS: The extension of Equations 18 is recommended for three-dimensional stresses. Then the strength is defined by one of the following equations:

$$\left.\begin{aligned} S_1' &= (1-p')S_1'' \pm S_e \\ S_2' &= (1-p')S_2'' \pm S_e \\ S_3' &= (1-p')S_3'' \pm S_e \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

When stress concentration is present the variable part of the stresses S_1', S_2' and S_3' should be multiplied by stress concentration factors, as previously explained.

The foregoing design code is an attempt to rationalize the determination of strength and working stresses for the various loading conditions encountered in machines. Any code dealing with materials and design cannot be too rigidly applied since information on material behavior, even with laboratory test specimens, is quite limited. There are also the uncertainties involved in using strength data for design purposes. Some of the many questions involved in the selection of factors of safety have been discussed in an attempt to rationalize working stress determination. Much more attention is usually given by the designer to the improvement of a stress analysis procedure than to the intelligent selection of the working stress

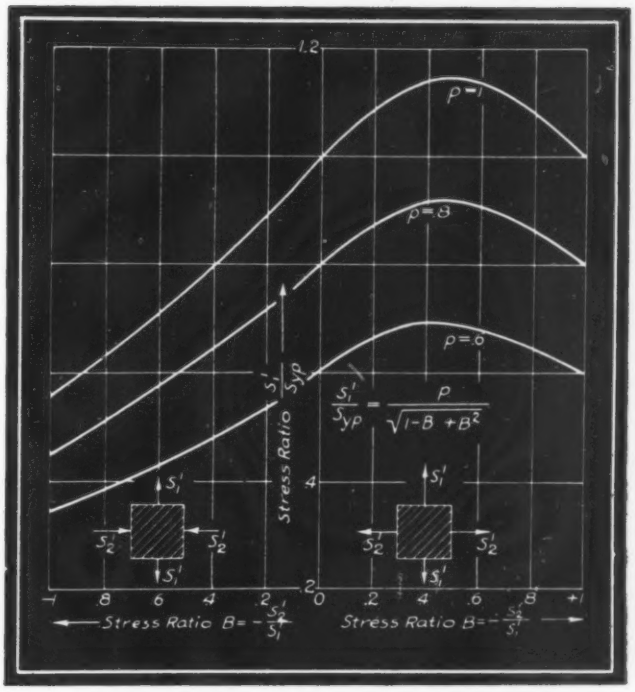


Fig. 14—Strength ratios for reversal of biaxial stresses

values. It is, however, apparent that the possibilities of weight reduction, economy and safety could sometimes be much greater if more attention were directed to the selection of a rational working stress.

Often the procedure outlined in this code cannot be applied conveniently. That is, the dimensions of the part have been based on some other requirement than strength. In addition, a particular method of stress analysis may have been used for many years and may be incorporated in the company's design data sheets. Under these circumstances it is still possible to consider the factors outlined without changing the well-established procedures. In place of a working stress value it is necessary only to obtain an equivalent simple static tensile stress by using the equations presented above. This stress can then be compared with that previously used to determine what difference these material factors make. It is this difference and the possible reduction in the factor of safety that are of practical interest and importance to the designer.

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Tests Reveal Stress ai

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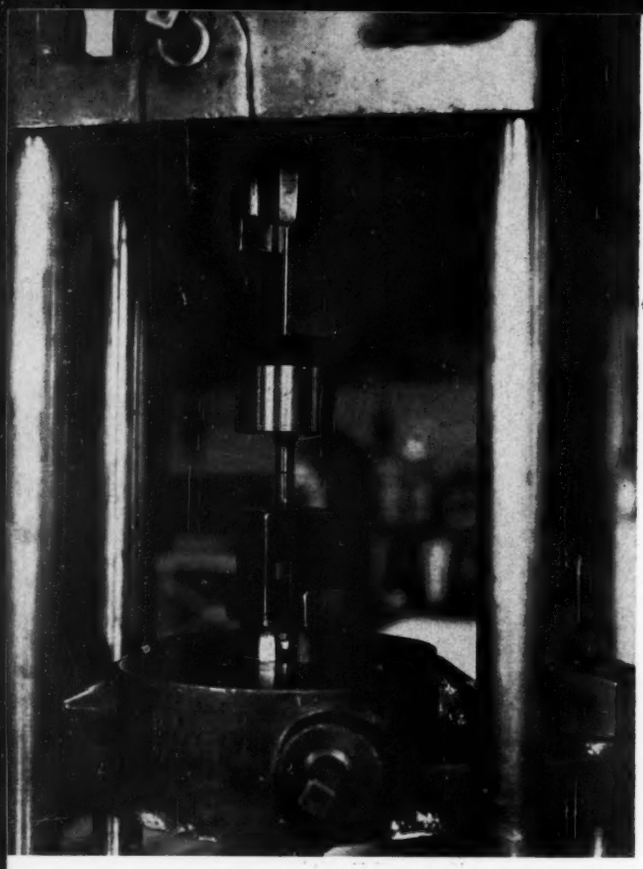


Fig. 1—Notched specimen is held in self-aligning tensile test fixtures

UNDER conditions of high stress concentration, ductile materials may fail in a brittle manner even under static loading. This article, abstracted from a paper presented at the recent annual meeting of the American Society for Metals in Cleveland, describes a notched bar tensile test which evaluates the characteristics of materials subject to stress raisers

VALUES found from an ordinary tensile test are not a sufficient criterion of the suitability of a steel for commercial applications involving shoulders, keyways, and other irregularities in shape that produce a similar effect to that of a deep notch. In particular, a test is desired in which the stress state can be varied sufficiently to cause either ductile or brittle failures of a steel which is normally ductile, but which might behave in a brittle manner under extreme service conditions.

It is generally believed that the addition of "transverse" stresses in both directions perpendicular to a major applied tension, resulting in a "triaxial tension", will reduce the ductility of metal. Any metal should become brittle if the triaxiality becomes sufficiently great, that is, if there is a sufficiently close approach to a state of "hydrostatic tension", in which the transverse tensile stresses equal the longitudinal stress.

A considerable amount of research has been carried out on the effect of notches on the behavior of steels and other metals subjected to static tension. However, it appears that the interpretation of the experimental results which are available at present is rather inconclusive and open to argument.

Therefore, notched bar tensile tests on several structural steels, heat treated to various strength levels, were conducted. These yielded a number of fundamental facts which apparently have not been previously recognized.

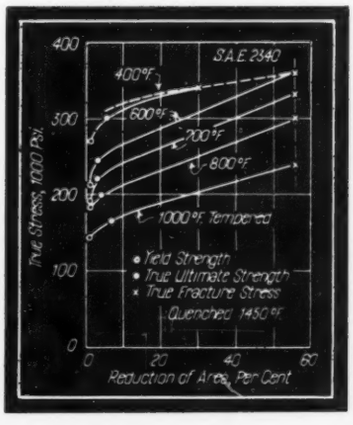
For the experimental investigation of the properties of notched bars, five open-hearth, ladle-killed alloy steels of the .40 per cent carbon class, SAE 2340, 3140, 4140, 5140, and T1340, were selected. This report deals mainly with the results obtained on the SAE 2340 steel. The other steels yielded fundamentally the same relations, although some complex phenomena in both the regular and the notched bar tensile tests were observed in these steels which have not been completely clarified as yet.

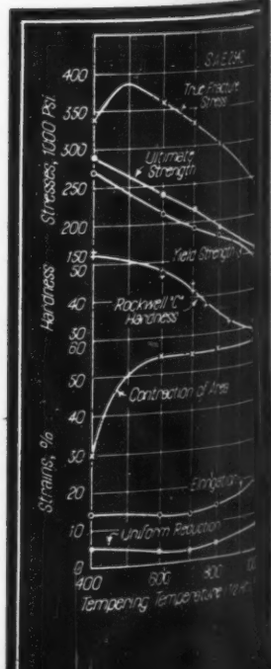
Suitable lengths of rod were prepared for the notched bar tensile tests by the following procedure: (a) standardizing heat treating, (b) preliminary machining, (c) quenching and tempering, (d) final machining, and (e) measurement of dimensions.

Results of the tests on unnotched specimens for the SAE 2340 steel are presented in *Fig.* 2. These tensile

Fig. 2—Right below—Results of tensile tests on unnotched specimens of SAE 2340 steel

Fig. 3 — Below — True stress-strain curves for unnotched specimens for various tempering temperatures





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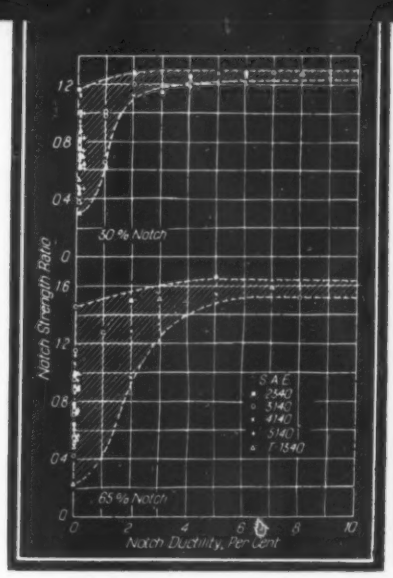
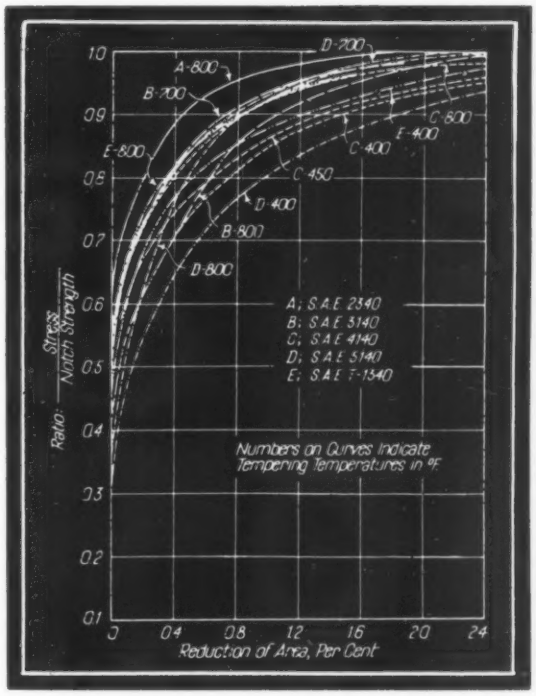


Fig. 5 — Right — Relation between notch-strength ratio and notch ductility

Fig. 6—Below—Derived stress-strain curves for 5 per cent notched specimens



test characteristics point to a rather general misconception regarding the suitability of a steel for practical applications. It is generally believed that a steel becomes increasingly valuable if the strength can be increased without serious loss in ductility, and a regular tensile test is the most common means of evaluating these properties. If this were true, then the SAE 2340 steel, the true stress-strain curves of which are represented approximately in *Fig.* 3, would be most suitable for high strength applications when tempered at a temperature of approximately 600 degrees Fahr., resulting in the most favorable combination of high strength and high ductility.

However, practical experience indicates that any steel becomes rather sensitive and prone to premature failure in service, particularly in applications which involve section changes and impact loads, if heat treated above a certain strength level. The general decrease of the impact with decreasing tempering temperature or increasing strength level (see *Fig.* 11) is considered as a manifestation and confirmation of such a relation, and the minimum of the impact strength at 600 degrees Fahr indicates particularly poor characteristics when tempered at this tempering temperature. Thus, the performance of a steel in practice, which as a rule involves stress raisers and sudden loads, cannot be judged by the characteristics as measured by regular tensile tests, the values of

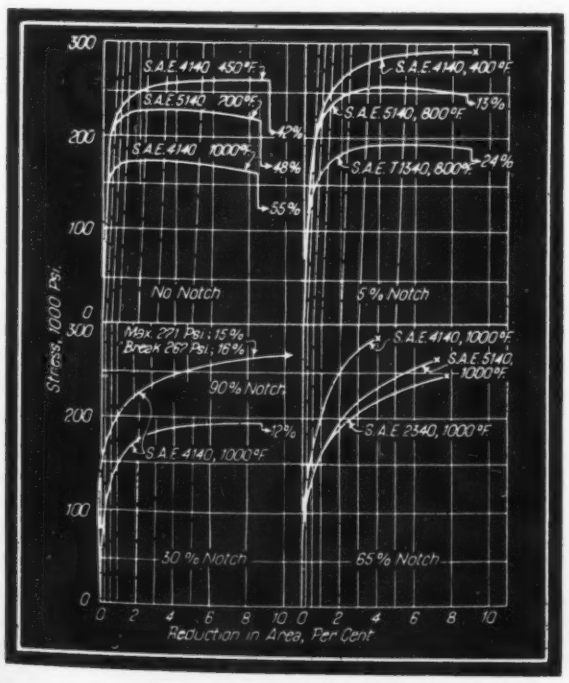


Fig. 4—Stress-strain curves for selected unnotched and notched bars at various tempering temperatures

contraction in area apparently being particularly misleading.

Notched specimens were provided with a circular V-shaped groove in the center of the cylindrical portion. The notches had an included angle of 60 degrees and a varying depth, removing anywhere from approximately 2 to 90 per cent of the cross-sectional area. In order to obtain a really sharp notch, most of the specimens were finished after heat treating with an equilateral file which had been ground smooth on two sides, forming a sharp 60-degree wedge. This procedure gave a sharp, V-shaped notch, except for the very hard tempers, above 50 Rockwell C, in which case the notch remained irregular and usually showed a sharp dent in the bottom of the fillet.

The most information was expected from a stress-strain curve for the notched section. Such a stress-strain relation can be obtained by plotting the force divided by the initial cross-sectional area of the notched section, or conventional stress, versus the reduction in cross-sectional area of the notched section. Both the stress and the strain are only averages of values which might vary considerably over the cross section, and their physical meaning has not been disclosed as yet. A number of stress-

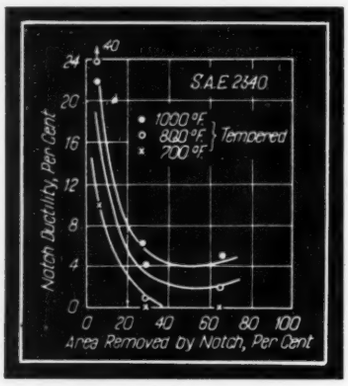


Fig. 7 — Effect of notch depth on notch ductility

strain curves obtained in this manner are represented in *Fig.* 4*.

The maximum load divided by the original cross-sectional area of the notched section yields a value corresponding to the ultimate strength of an unnotched specimen. This average strength is designated as "notch strength." "Notch ductility" is defined as the contraction in area, or reduction of cross-sectional area of the notched section after failure. In tests on specimens having a soft temper, failure at a load below the maximum was frequently observed and the load recorded. The ratio between this breaking load and the cross-sectional area of the notch after failure is introduced as (true) "fracture stress."

In spite of certain difficulties, the tests performed so far reveal a number of hitherto unknown relations regarding the notch strength of heat treated alloy steels. While the quantitative values will be open to considerable argument, the qualitative results obtained reveal a picture of the notch effects which is in agreement with the theoretical conceptions.

The notch strength is dependent upon numerous factors such as, particularly:

(a) Chemical composition of the steel
(b) Ultimate strength or "strength level" of the steel
(c) Shape of the notch as determined by depth, notch angle, and bottom radius.

For a notch of given shape, however, the ratio between notch strength and ultimate strength has been found frequently to be approximately the same, and to be rather close to 2 to 1 for a notch of extreme depth (100 per cent) and sharpness. Furthermore, a general survey of the data presented has revealed the fact that notch strength ratio, for a given notch, depends only upon the notch ductility, as illustrated in *Fig.* 5 for the specimens having a 30 per cent and a 65 per cent notch.

While the physical meaning of the "notch ductility" has not been adequately explained as yet, both previous and new experimental data indicate that the notch ductility is subject to the most fundamental generalizations. The complex behavior of other properties is partially explained by the simpler variations of the notch ductility.

Fig. 5 shows clearly two different ranges regarding the notch strength ratio. Bars having a notch ductility above a certain value, which is approximately 5 per cent for all the investigated steels, possess a practically constant notch strength ratio. This ratio is 1.25 ± .05 for such "ductile" specimens with a 30 per cent notch and 1.6 ±.05 for specimens with a 65 per cent notch. The scattering of the values is small, indicating a uniform condition which is little affected by variations in chemical composition, heat treating, and testing.

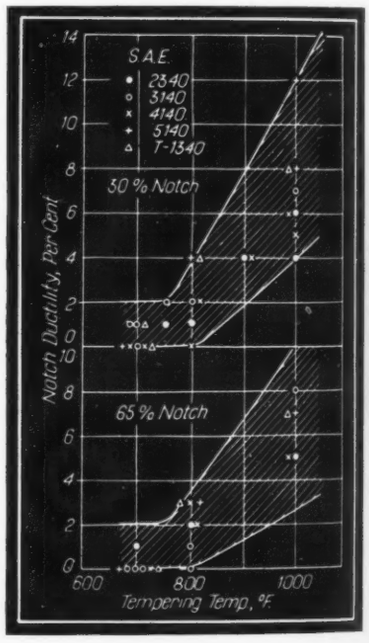


Fig. 9 — Effect of tempering temperature on notch ductility of the various alloy steels

On the contrary, "notch brittle" bars having a notch ductility of 1 per cent or less may possess a notch strength ratio anywhere between a low value of approximately .2 to 1 and a value close to that for the ductility specimens. The source of this tremendous scattering of the notch strength ratios for such notch brittle steels cannot be fully explained as yet.

If the scattering is disregarded, the shape of the notch strength ratio versus notch ductility curves, *Fig.* 5, has the appearance of conventional stress-strain curves. This is more than a mere superficial similarity, but has a real and fundamental significance. The stress-strain curves in *Fig.* 4, for different steels and different temperatures, but for the same notch, are quite similar. If the curves for various ductile specimens are plotted in such a manner that their maximum load is selected as unity, they appear sufficiently alike to justify the simplifying assumption that for a given notch the stress-strain curves converted in this way are identical. This approximate similarity is illustrated in *Fig.* 6 for specimens having a 5 per cent notch.

*These curves are approximate, but illustrate qualitatively the effects of notching.

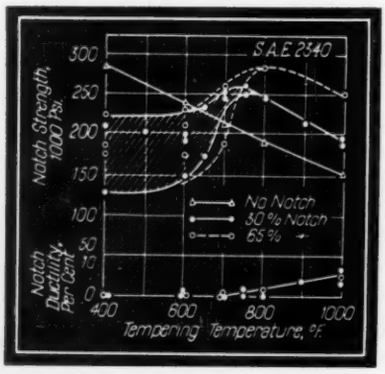


Fig. 8 — Effect of tempering temperature on notch strength and notch ductility for SAE 2340 steel

The changes in the tensile test characteristics caused by notching cannot be adequately explained without a thorough knowledge of the external and internal effects introduced by variations in notch depth. Therefore, this phase of the program has been investigated in a particularly extensive manner.

Again, the notch ductility appears to be the property which is subject to the simplest relations. The notch ductility versus notch depth curves for conditions where the ductility is measurable over a considerable range of notch depth, *Fig.* 7, illustrates the universal effect of notch depth on notch ductility. For a moderately deep notch many of the conditions of composition and tempering temperature which have been investigated cause complete brittleness, that is, a contraction in area smaller than 1 per cent. In all these instances, a further increase of notch depth does not cause any noticeable increase of ductility again.

If the notch ductility of a deeply notched specimen is above a certain small value, approximately 2 to 3 per cent, the notch strength increases with the area removed by the notch. The rate of this increase is such that the limiting, 100 per cent notched, condition would have a

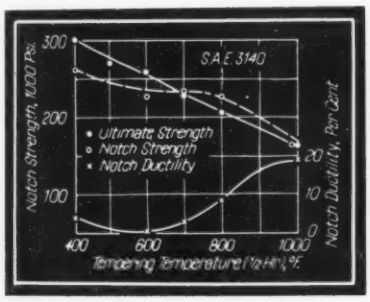


Fig. 10—Effect of tempering temperature on notch strength and notch ductility of 5 per cent notched SAE 3140 steel

notch strength between 1.7 and 2 times the ultimate strength of the unnotched specimen. Alloy and strength level have a slight effect on this limiting notch strength ratio. This relation is limited to steels having a strength below 210,000 pounds per square inch.

For notch brittle conditions, it appears that the notching of steels having a high strength level changes the strength little at first, but then, with increasing notch depth, large scattering is introduced. The highest values of notch strength obtained might be considerably higher than the ultimate strength of the unnotched specimen while the lower limit might be as low as 20 to 30 per cent of the ultimate strength.

The strength level of a particular alloy steel is primarily determined by the temperature of tempering, proper quenching being assumed. Therefore, the results of notched bar tensile tests on alloy steels are decidedly dependent upon the tempering treatment applied after having hardened the steel. This is apparent from the data selected for bars provided with 30 and 65 per cent notches. These data are replotted in *Fig.* 8 versus the tempering temperature.

The assembly in *Fig.* 9 of the notch ductility values for the various steels tempered at various temperatures reveals the fundamental fact that the notch ductility of any of the steels investigated decreases progressively with decreasing tempering temperature. When tempered for one-half hour below a temperature of 800 degrees Fahr.

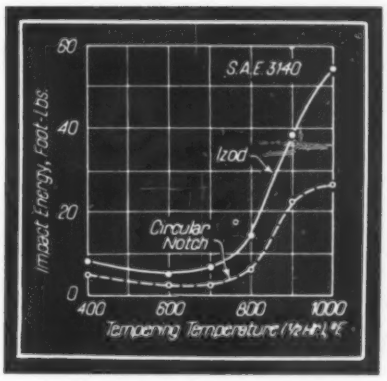


Fig. 11—Results of two types of notched bar Izod impact tests on SAE 3140 steel

the notch ductility of all the steels investigated is 1 per cent or less, and within the present limits of accuracy, the steels are completely brittle.

The notch strength, *Fig.* 8, illustrates the fundamental effect of tempering temperatures, particularly for the temperature range below 800 degrees Fahr. At higher temperatures, the notch strength is higher throughout than the ultimate strength of the unnotched specimen by a nearly constant factor, as previously discussed. This condition prevails for tempering temperatures down to approximately 800 degrees Fahr. but it is radically changed at this point. The notch strength decreases somewhat at first and at the same time the scattering appears. This scattering becomes very large if the tempering temperature is 600 degrees Fahr. or lower, the maximum values being slightly above the ultimate strength. Thus, the notch strength values seem to indicate a radical difference in the notched bar characteristics of the steels, depending on whether they are tempered at temperatures below or above a certain temperature which is approximately 800 degrees Fahr.

Such a conclusion, however, is fundamentally erroneous. Steels showing a contraction in area of, say, 5 per cent, are not considered as particularly ductile. But this is the average ductility of 30 to 65 per cent notched tensile test bars, quenched and tempered at a temperature of approximately 900 degrees Fahr. and having a strength between 170,000 and 200,000 pounds per square inch. Thus, deep notching creates a severe embrittlement in that it reduces the contraction in area of an unnotched specimen from 50 per cent or more to 5 per cent; but this is not apparent from the notch strength values.

The effects of notching on steels having a strength level over 200,000 pounds per square inch are also illustrated by the notch ductility of bars of the SAE 3140 steel provided with a shallow notch, *Fig.* 10. The ductility of such specimens also decreases with decreasing

(*Concluded on Page* 190)

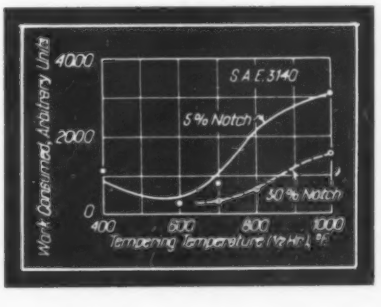


Fig. 12—Work consumed in tensile tests on notched bars of SAE 3140 alloy steel

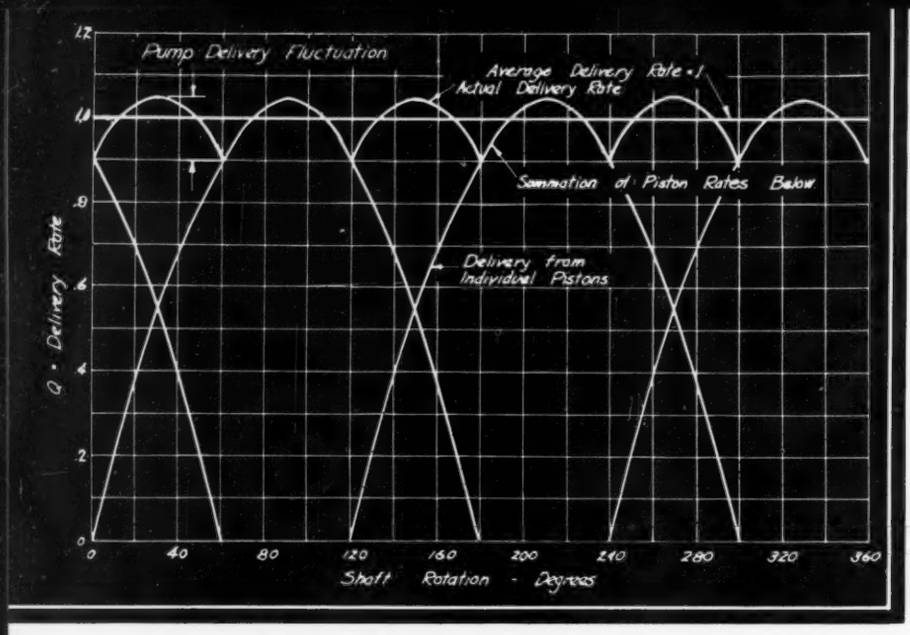


Fig. 1—Delivery rate for three-cylinder pump having sinusoidal piston motion. Pulsation frequency is six times shaft speed

Controlling

By Christian E. Grosser
Massachusetts Institute of Technology

EFFICIENT transmission of power at variable speeds by the use of hydraulic displacement machinery was rendered practicable by the advent of relatively smooth flow multiple piston pumps and fluid motors as well as multiple vane and gear units which came a little later. The designer of today can choose from a considerable variety of equipment when laying out a variable transmission or control system. (For illustrations of typical machines of these designs, the reader is referred to a previous article "How to Select Hydraulic Power Equipment," MACHINE DESIGN, April, 1941.

While current designs of pump and motor equipment exhibit reasonably smooth flow characteristics for a uniform shaft speed, some degree of pulsation still exists. The achievement of the ideal in a displacement machine, that is, one having an absolutely uniform flow characteristic, is not yet in sight. Consequently, applications of hydraulic equipment must tolerate vibration, pressure variations and noise to a certain extent. Through an acquaintance with the origin, nature, and magnitude of flow pulsations in the various types of units, the designer is enabled to decide how much effect the characteristics of each may be expected to have in a proposed application and he may therefore more judiciously choose his hydraulic equipment and take such precautions as may be necessary to the application.

This article describes in detail the mechanisms by which liquid passes through a displacement unit, and the consequent variations in flow. An analysis is given of how, and to what extent, the fluctuations in flow produce pressure pulsations in the flow system. The effect of pressure pulsations on the connected machinery also is analyzed, with suggestions for reducing them to a minimum where they may be important.

Because of relatively low slip and high efficiency, piston type equipment is preferred for larger capacity power transmissions and for closely coupled control systems. However, as will be brought out in the course of the discussion, the potential effects of flow pulsations are most troublesome with this type.

With few exceptions the stroke-actuating mechanisms in multiple-piston units give sinusoidal motion to the pistons so that the velocity of the pistons in an n-cylinder machine may be described by the equation,

$$\text{velocity of No. 1 piston} = v_1 = a \sin \theta,$$

$$\text{velocity of No. 2 piston} = v_2 = a \sin [\theta + \alpha],$$

$$\text{velocity of No. 3 piston} = v_3 = a \sin [\theta + 2\alpha],$$

$$\text{velocity of No. } n \text{ piston} = v_n = a \sin [\theta + (n-1)\alpha], \quad \ldots (1)$$

where θ = shaft angle from position when No. 1 piston is on dead center and about to begin its discharge stroke

α = angle between cylinders = 360/n degrees

a = maximum piston velocity
= ½ (total stroke) × (shaft speed)
= (π/60) × (total stroke, inches) × (shaft rpm), inches per second.

TABLE I

Pulsations in Piston Pumps

No. of Pistons	Pulsations (per Revolution)	Fluctuation (% avg. flow rate)
3	6	14.1
5	10	5.0
7	14	2.6
9	18	1.5
11	22	1.0
13	26	0.7

With θ defined as above, the expressions in Equation 1 give the velocity of discharge for each piston when the quantities on the right come out positive, that is for one-half resolution, while $[\theta + (n - 1)\alpha]$ varies from 0 to 180 degrees. When the sign is negative, the velocity is in the reverse direction, which is to say the piston is on the suction stroke.

The discharge rate of each piston is then simply

ng tions in Hydraulic Equipment

$$v_n A_p = a\ A_p\ sin\ [\theta+(n-1)\alpha] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where A_p is the piston area.

The total discharge rate Q of a pump having n cylinders

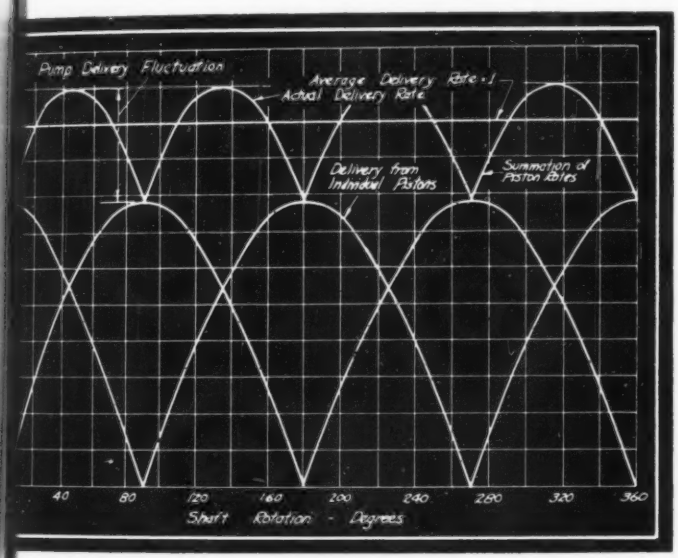


Fig. 2—Four cylinder pump has high fluctuation in delivery rate. Sinusoidal piston motion assumed

at any given shaft angle θ will be

$$Q_{discharge} = A_p(v_1+v_2+v_3+---v_n)$$

$$= A_p\ a\ \{\underbrace{sin\ \theta + sin\ [\theta+\alpha] + sin\ [\theta+2\alpha]}_{\text{positive terms only}}$$

$$\underbrace{+---sin\ [\theta+(n-1)\alpha]}_{\text{positive terms only}}\} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$Q_{suction} = A_p(v_1+v_2+v_3---v_z)$$

$$= A_p\ a\ \{\underbrace{sin\ \theta + sin\ [\theta+\alpha] + sin\ [\theta+2\alpha]}_{\text{negative terms only}}$$

$$\underbrace{+----sin\ [\theta+(n-1)\alpha]}_{\text{negative terms only}}\} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Q is never exactly a constant value, but fluctuates as the shaft angle θ goes through a complete cycle of 360 degrees. Generally speaking the degree of fluctuation decreases as n (the number of pistons) increases, as would be expected. However, there is a sharp difference in discharge flow fluctuations between those for even and those for odd values of n. This is illustrated in *Figs.* 1 and 2 showinf graphically the delivery characteristics, as expressed by Equation 3, of a three-cylinder machine and a four-cylinder machine respectively. The three-cylinder machine exhibits six fluctuations per revolution, which is exactly the same characteristic as that for a six-cylinder machine, whereas the four-cylinder unit has only four fluctuations per revolution, of much larger magnitude. Properly designed piston units with sinusoidal stroking are therefore always made with an odd number of pistons.

Smooth Operation Versus Low Cost

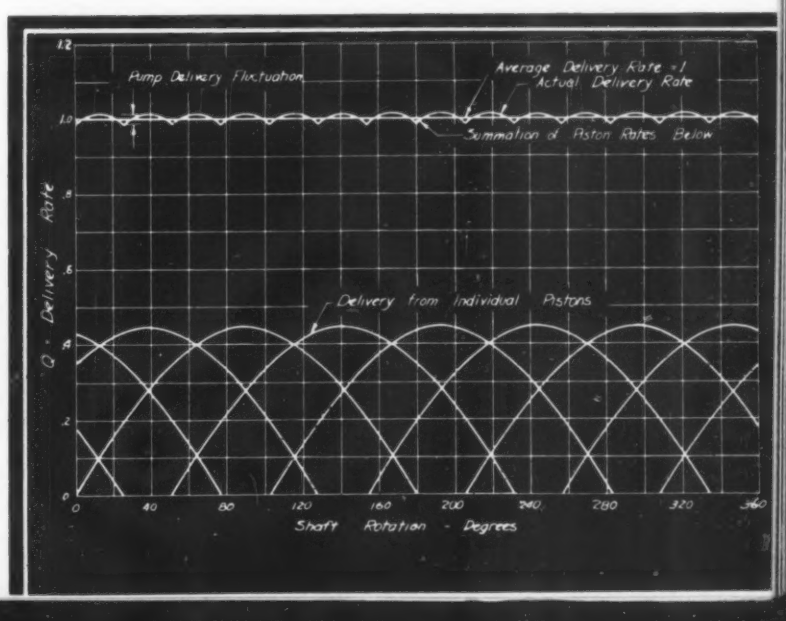
Commercial piston type units usually incorporate either seven or nine pistons. Occasionally five or even three-piston designs are encountered where simplicity and lower cost of manufacture are more important factors than smooth operation. On the other hand a few units have been made with eleven and thirteen cylinders, in cases where the cost was secondary to the need for a minimum of flow variation. *Fig.* 3 illustrates the discharge rate of the commonly used seven-cylinder combination. TABLE I gives the overall fluctuation with various piston numbers.

As an indication of the extent of fluctuations in gear and vane units *Figs.* 5 and 7 are shown. *Fig.* 4 illustrates a gear pump with two 17-tooth gears in engagement only slightly more than one normal circular pitch, so that oil trapping at the mesh is avoided. The variation in displacement rate may be studied in a simple manner by taking advantage of the relationship, holding for all types of displacement machines whether pumps or motors,

$$T = \frac{\Delta p\ D}{2\pi}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where T = shaft torque

Fig. 3—Pulsation from seven-cylinder pump is relatively slight



Δp = pressure difference across the unit outlets

D = displacement per revolution.

It is a difficult matter to measure the displacement rate from a study of the tooth contours and the volumes of oil conveyed in the tooth spaces. However, it is relatively easy to observe the torque effects of the pressure on the tooth surfaces, and since Equation 5 shows that the variations in torque are directly proportional to the displacement rate it is convenient to attack the fluctuation problem from this approach.

Referring to *Fig.* 4 it will be noted that at the beginning of contact at point *a* the high pressure acts on an exposed, unbalanced, projected area of tooth surface of the driver which (for unit face width) is

$$A_{driver}=r_o-r \quad \ldots\ldots (6)$$

which produces a resisting torque (in the case of pump action) of

$$T_{driver}=(r_o-r)\Delta p\frac{(r_o+r)}{2}=\Delta p\frac{(r_o^2-r^2)}{2} \quad \ldots\ldots (7)$$

Similarly the driven gear has an exposed unbalanced tooth area of

$$A_{driven}=r_o-r_1 \quad \ldots\ldots (8)$$

which produces a resisting torque of

$$T_{driven}=(r_o-r_1)\Delta p\frac{(r_o+r_1)}{2}=\Delta p\frac{(r_o^2-r_1^2)}{2} \quad \ldots\ldots (9)$$

The total torque, which holds in the case illustrated for all points on the line of contact, is then

$$T_{shaft}=\Delta p\left[r_o^2-\frac{(r^2+r_1^2)}{2}\right] \quad \ldots\ldots (10)$$

where r = radius from the center of the driver to the point of contact

r_1 = radius from the center of the driven gear to the point of contact and

r_0 = radius to the ends of the teeth.

The similarity between Equations 5 and 10 shows immediately that (for a unit face width)

$$D=2\pi\left[r_o^2-\frac{(r^2+r_1^2)}{2}\right] \quad \ldots\ldots (11)$$

The analytical evaluation of r and r_1 is difficult, and therefore it is not convenient to set up a general expression which will give the variation of the displacement rate D for all combinations of tooth numbers and addendum lengths. Furthermore, in the illustrated case only one tooth is in contact at a given time. If more than one tooth is in mesh the oil between contacts is trapped and is relieved by porting to the high pressure side of the mesh away from the relief port.

In the case shown by *Fig.* 5, the total variation in displacement is 21 per cent of the average, which is typical of units with small numbers of teeth. There are, of course, as many fluctuations per revolution as there are teeth.

A similar type of analysis may be made for the vane type pump, of which *Fig.* 6 is a typical example. Again the moment of the unbalanced vane area exposed to the high pressure (over the upper half of the rotation), in passing over the right-hand land between ports, is proportional to the displacement rate. In the example shown of a 15-vane machine the fluctuations in flow are somewhat less than one half of one per cent of the average flow rate, which shows that vane-type machines have a very smooth characteristic. The illustrative graph of the fluctuations, *Fig.* 7, shows an exaggerated amplitude.

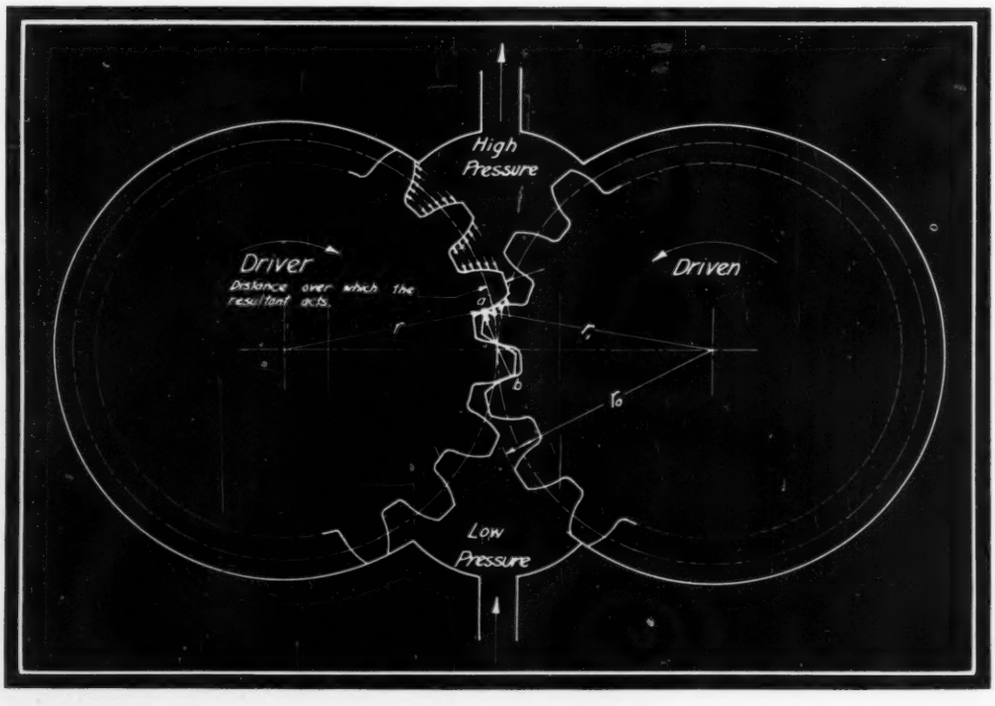


Fig. 4—Torque analysis of gear pump furnishes expression for theoretical delivery rate

Having considered the character of flow fluctuations which may be encountered in hydraulic equipment and having established the method by which their magnitudes may be measured, it is pertinent to examine the effects of such fluctuations in a hydraulic transmission system.

Fundamentally the consequence of a fluctuation in flow rate between the pump and fluid motor is a forced oscillation of the mass of the driving element at the input to the transmission and an accompanying forced oscillation of the mass of the driven load element connected to the output of the transmission.

Important factors affecting the oscillations are: Amplitude of the flow fluctuation and its frequency; elastic constant of the transmission system; the characteristic leakage rate; the mass of the connected parts; and the displacement per revolution of the pump and of the motor.

On the basis that the flow fluctuations are sinusoidal the amplitude of the driven mass relative to the driving mass is given by the following expression, assuming that

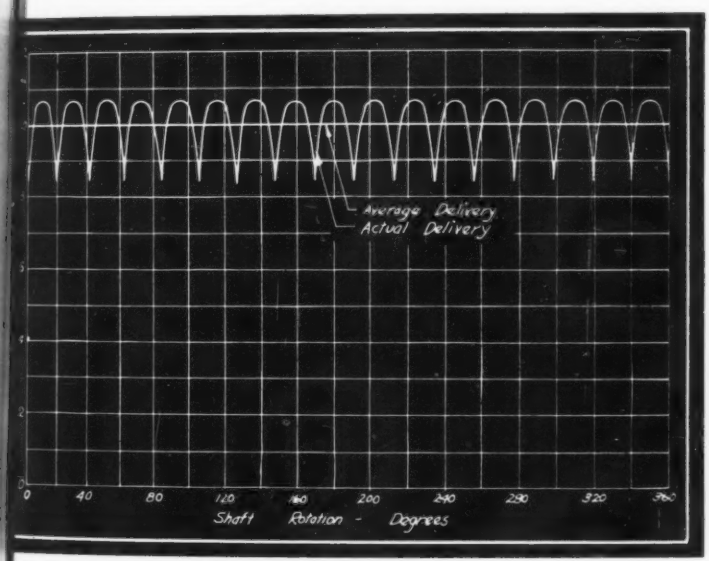


Fig. 5—Theoretical pulsation in delivery rate for gear pump having 17 teeth

pump and motor are of the same size:

$$\theta_i+\theta_o=\frac{2\pi Q_f}{D\omega_f}\frac{\sqrt{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)^2+\left(\frac{4\pi^2k_2I\omega_f}{D^3}\right)^2}}{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)^2+\frac{16\pi^4k_1k_2^2I}{D^4}} \quad \ldots\ldots (12)$$

where θ_i = amplitude of the driving mass, radians

θ_o = amplitude of the driven mass, radians

Q_f = amplitude of the flow fluctuations, cubic inch per second

D = displacement of the pump, cubic inch per revolution

ω_f = forcing frequency of the flow pulsations, radians per second

ω_n = natural frequency of the system, radians per second

k_1 = elastic constant of the system, inch-pounds per radian

k_2 = leakage constant, cubic inch per second per pounds per square inch pressure

I = equivalent moment of inertia, pounds-inch-second^2.

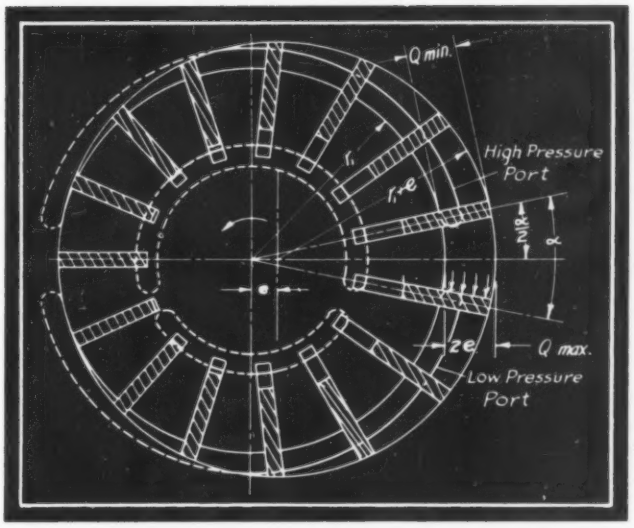


Fig. 6—Vane pump analysis leads to equation for theoretical delivery rate

The equivalent moment of inertia, I, may be expressed in terms of the moments of inertia of separate elements by

$$I=\frac{I_iI_o}{I_i+I_o} \quad \ldots\ldots (13)$$

where I_i = moment of inertia of the input elements

I_o = moment of inertia of the output elements.

The elastic constant k_1 of the system is obtained from,

$$k_1=\frac{1}{\frac{1}{k_a}+\frac{1}{k_b}+\text{-------}\frac{1}{k_n}} \quad \ldots\ldots (14)$$

where k_a, k_b, etc. are the elastic constants of all the members between the driving and driven masses, including that of the oil in the system and that of the connecting piping. The constant for the oil in the system is obtained from the relationship

$$k_{oil}=\frac{E_vD^2}{4\pi^2V} \quad \ldots\ldots (15)$$

where E_v = bulk of modulus of oil, approximately 200,000 pounds per square inch

D = displacement per revolution of the pump or motor

V = volume of oil in system.

The natural frequency ω_n is obtained from the relationship

$$\omega_n=\sqrt{\frac{k_1}{I}} \quad \ldots\ldots (16)$$

The amplitudes of the output and input masses bear

the relation

$$\frac{\theta_i}{\theta_o}=\frac{I_o}{I_i} \quad \ldots\ldots(17)$$

The assumption of sinusoidally varying flow fluctuations in Equation 12 is made since the derivation for the discontinuous "scallop" form of variation is extremely tedious and renders a result difficult to interpret. The error introduced by the substitution of an equivalent sinusoidal wave form of perhaps two-thirds the amplitude of the "scallop" is known to be small.

The expression for the amplitude of pressure pulsations P in the system is

$$P=\frac{4\pi^2 I Q_f \omega_f}{D^2}\,\frac{\sqrt{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)^2+\left(\frac{4\pi^2 k_2 I \omega_f}{D^2}\right)^2}}{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)^2+\frac{16\pi^4 k_1 k_2^2 I}{D^4}} \quad \ldots\ldots(18)$$

where P = system pressure in pounds per square inch and the other quantities are as previously defined, following Equation 12.

Because of the many factors involved it is difficult to

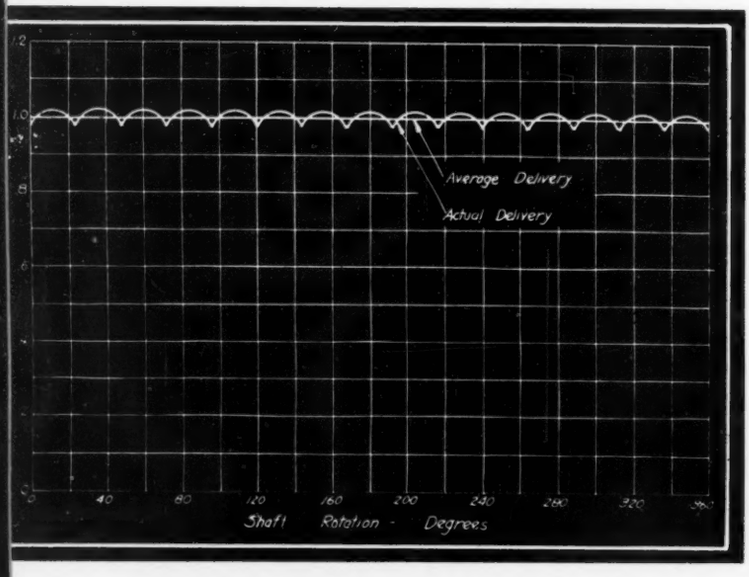


Fig. 7—Pulsations shown for vane pump with 15 vanes are exaggerated about ten times

draw many broad generalizations from a simple inspection of Equations 12 and 18. For important cases it is, of course, best to approximate the constants of a proposed design and substitute them directly into the equations, noting how those factors susceptible to control in the design affect the degree of oscillation and pressure pulsations. However, a few conclusions may be pointed out for general guidance to the designer of a hydraulic transmission or control circuit.

The effect of the rate of leakage out of hydraulic system may be roughly estimated by considering extremes. If no leakage is permitted, that is $k_2 = 0$, Equations 12 and 18 reduce to:

$$(\theta_i+\theta_o)_{k_2=0}=\frac{2\pi Q_f}{D\omega_f}\,\frac{1}{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)} \quad \ldots\ldots(19)$$

and

$$P_{k_2=0}=\frac{4\pi^2 I Q_f \omega_f}{D^2}\,\frac{1}{\left(1-\frac{\omega_f^2}{\omega_n^2}\right)} \quad \ldots\ldots(20)$$

This means that for tight equipment such as closely fitted piston units it is important to avoid resonance between the natural frequency ω_n, and ω_f the forcing frequency, since the magnification factor $1/(1 - \omega_f^2/\omega_n^2)$ becomes critically large as the two approach the same value. The object is to keep the forcing frequency, ω_f to a high value by using a large odd number of pistons and to depress the natural frequency ω_n. The latter may best be accomplished by reducing the stiffness of the system, that is by reducing the constant k_1 either through introducing flexible couplings between the transmission and the connected masses, or spring loaded pistons in the pressure system. Another method is to increase the equivalent mass I, which reduces the amplitude of oscillation, but increases the amplitude of pressure pulsations.

In high-performance displacement servo or "follow-up" systems, reduction in the stiffness k_1 and increase of equivalent mass are undesirable in that such tendencies tend to increase the errors of response. The only alternative in such cases is to increase ω_f by using a larger number of pistons.

Moderate Pulsation Sometimes Desirable

Certain servo designs have found it desirable not to reduce the oscillation too far in that a moderate amount tends to break loose the controlled load from static friction in such cases where the load comes to rest and must be moved only a small amount.

Sensitivity of the low-slip piston type units to vibration and pulsation is much greater than that of the gear and vane types which have inherently high leakage characteristics. Despite the relatively large amplitude flow fluctuations of gear pumps and motors they rarely give pulsation trouble because of high k_2 value and high ω_f with moderately large numbers of teeth, so that resonance is avoided.

The vane unit is exceptionally smooth because of its inherently low fluctuation amplitude Q_f, and because the k_2 value is large relative to piston equipment. It should be clear that the values of Equations 12 and 18 reduce substantially as the value of k_2 increases. However, the efficiency of such a system with a vane pump is poor.

Examining another extreme condition shows that if the equivalent inertia I is increased, keeping the natural period ω_n constant, that is heavy masses with a rigid connecting system, the pressure pulsations become very high in amplitude. The remedy in such a case is to increase the displacement D of the hydraulic units particularly where the leakage rate k_2 is small.

It is important to note that the fluctuation amplitude Q_f may be the sum of the variations of pump and motor, when they come into proper phase relation.

Composite Stampings Relieve Critical Shortages

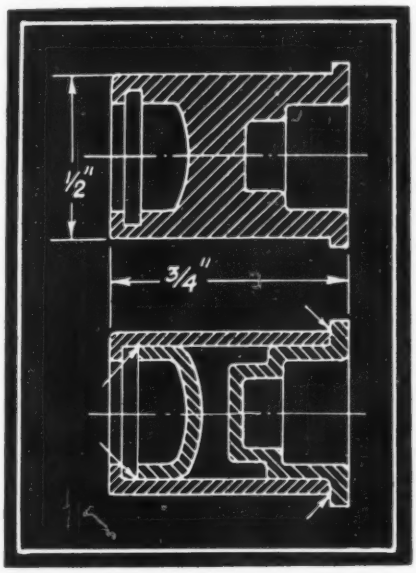


Fig. 1—Shell component, originally solid brass (upper), is now a composite stamping (lower). Outside dimensions are identical in both parts

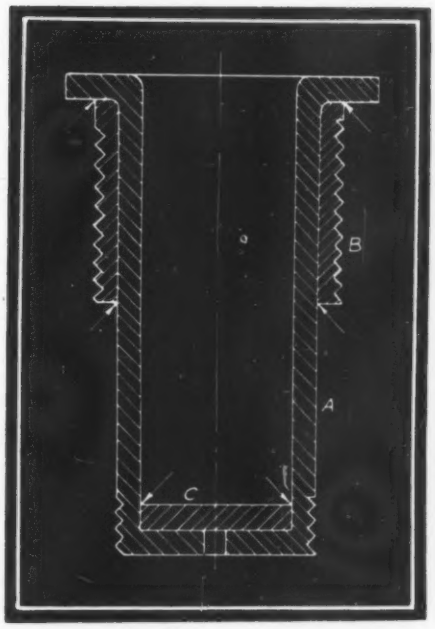


Fig. 2—Three stampings, brazed at points indicated by arrows, replace a machined part for this booster adapter

By G. W. Birdsall

AS pointed out by the Ordnance department in one of its recent publications, there is no advantage in our producing three times as much steel as the Axis if the Axis makes theirs go three times as far.

Thousands of ordnance items that we are now making from critical materials on critical machines must be made from less critical materials on less critical machines.

When a single contract calls for hundreds of millions, a saving that at first glance appears insignificant comes to assume tremendous importance. *Fig.* 1 shows such an example. This primer case, formerly machined from solid bar stock, is now made from three steel stampings, brazed together. This alone will save 23,352,000 pounds of brass on projected ordnance requirements through 1943. Against this saving there is a small amount of copper consumed in the copper brazing operation. However, the consumption is extremely small since a pound of copper will braze more than 1000 parts.

For the brazing operation, a piece of copper wire is fastened to the part at the two places indicated by the arows in *Fig.* 1. As the assembly is heated in the furnace, the copper melts and is drawn into the joint by capillary attraction. This produces an extremely strong joint, the final part being fully able to handle the job of the solid brass part.

One of the most important developments to be made so far is the shell component shown in *Fig.* 2. This changeover to a composite stamping is important not only because it saves material but also because it eliminates much machining time. Since such parts are made by the million, these advantages are particularly significant.

As originally made, this part was machined from a solid piece cut from

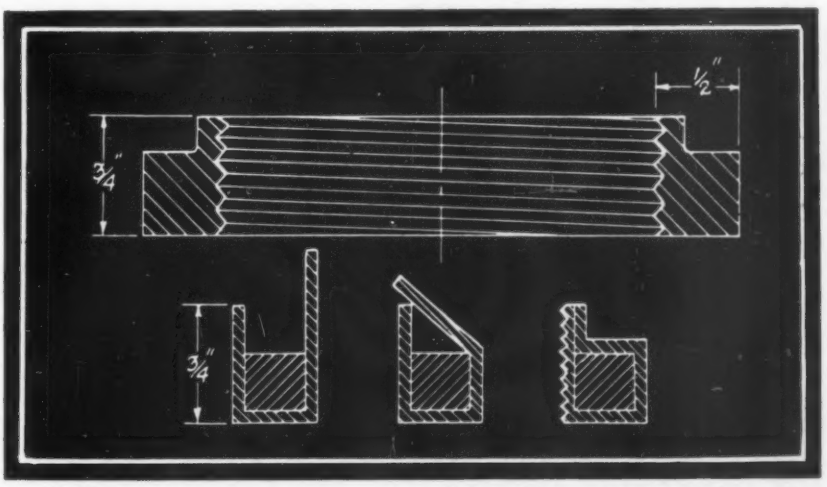


Fig. 3—Upper view shows locking ring as originally machined from a forging casting or thick-walled tubing. Lower sketches show successive stages in making equivalent part by stamping and forming

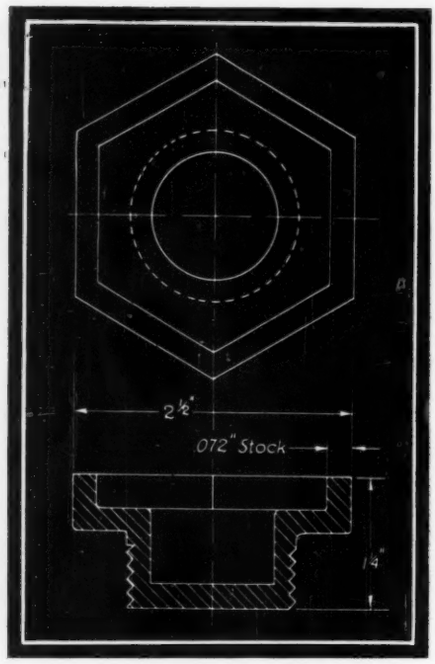
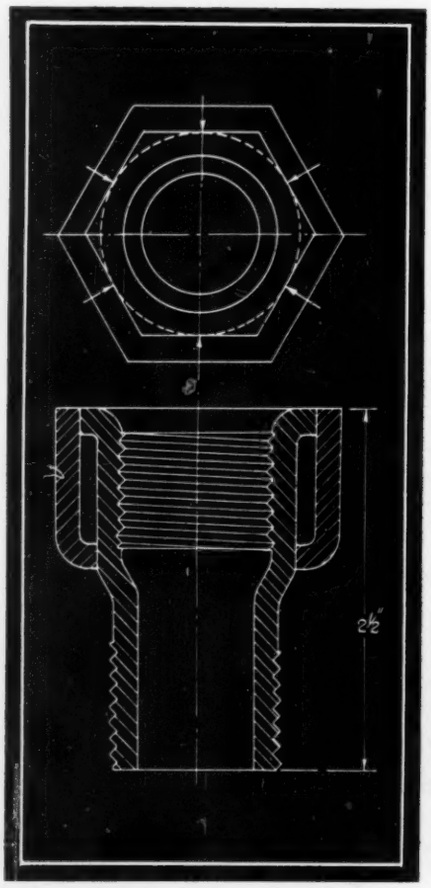


Fig. 4—Above—Made as a stamping, this plug requires no machining, the threads being formed by rolling

Fig. 5—Below—Adapter is made from two steel stampings joined by spot welds at points shown by arrows



cold-drawn steel bar. Each piece required 3.85 pounds of stock and .23 machine hours. Made as a composite stamping, it is produced from three pieces of 3/16-inch hot-rolled sheet, a material much less critical than the cold-drawn bar stock. The sheet is SAE 1010 or 1025 material. Since only 1.81 pounds of this stock is required for each composite stamping, a saving of over 2 pounds of metal is made per piece.

It is estimated that the total saving made by this change could easily amount to 25,000 tons yearly. On an order for 1,500,000 units alone, enough steel will be saved to make 3060 one-ton bombs.

Referring to *Fig.* 2, the big cup, *A*, is made in three draws. Then the small cup, *B*, is made in a single draw. To conserve an additional amount of metal the disk, *C*, is obtained by blanking out of the bottom of the small cup. Then it is trimmed to fit inside the large cup, and utilized as the bottom disk.

After the three units are assembled in a press, copper brazing rings are applied at the positions indicated by arrows, and the assembly is copper brazed in a furnace, heated to brazing temperature which is just a little above the melting point of copper, 1980 degrees Fahr.

Stampings Obviate Machining

One type of part which must be made in large quantities is the locking ring shown in *Fig.* 3. These rings vary from 4.5 to 6 inches in diameter. They were previously forgings, steel castings or machined from thick-wall tubing.

An ingenious method of making these rings is illustrated in the lower part of *Fig.* 3, showing how an interchangeable equivalent item is produced by a series of stamping and forming operations, using a formed sheet metal piece and a length of rod formed into a circle. There are several advantages of this method. It eliminates all machining, except threads and spanner wrench holes. Formerly this required 4.13 minutes per piece. At the same time it enlists the production capacities of small presses. Also it releases forging capacity formerly required to produce the part as a forging. In addition, a less critical material is being used since sheet steel is readily available in large quantities as compared with forging steel.

The method of making this locking ring, as can be seen from *Fig.* 3, consists of an unusual sequence of operations. A flat ring of sheet steel considerably larger than the diameter of the locking ring is first stamped out. In a series of drawing operations, two walls are formed as shown in the cross section, left. Then a length of rod formed into a circle of the correct diameter is inserted as shown.

In the next operation, center sketch, the outside vertical wall of the ring is bent down, starting to close the sheet metal portion around the solid portion. In the right-hand view the outer wall of the ring has been closed entirely around the solid section by being placed between a pair of dies in a press. All of these press operations are fairly simple and can be done at high speed. Too, dimensional accuracy is made high by the dies employed in closing the ring.

Cost Is Reduced One-fourth

Finishing the ring is accomplished by cutting the threads on the inner circumference as shown at right. This is a simple operation which is done at high speed in an ordinary drill press, only ½-minute being required for the operation. This is against 4.13 minutes for machining when the part was made as a forging. Thus the same section as in the upper view has been duplicated to meet the physical properties and dimensional requirements, forging and machining capacity have been released, stamping and forming presses and drill presses have been utilized, less critical material has been employed—accompanied by a cost reduction of 25 per cent.

Another part in which a saving in cost was made as well as the release of important machine capacity is shown in *Fig.* 4. This plug was originally

made from solid bar stock on a screw machine using .95-pound of material for each part. Production time was 1 minute per piece. As will be seen from the figure, this plug has threads on the outside and a hexagon head for applying torque.

Redesigned as a stamping, it is made from .15-inch stock, now plain SAE 1010 steel. To produce the shape shown in *Fig.* 4, the part is first blanked out from the sheet, then drawn to the depth desired. Following this it is redrawn to produce the hexagon head, and then it is sized in a final operation.

Rolled Threads Effectively Utilize Metal

Threads are produced by a rolling operation. In this manner no metal is removed from the cross section, the rolling dies simply forcing the metal to flow up to form the threads. This makes most efficient use of all the steel in the section. What is more important, it entirely eliminates machining.

Equally valuable is the significant saving in the material. The part needs only .42-pound of sheet steel, a comparatively abundant material. This means a reduction in material of almost 55 per cent.

Cost reduction made possible by this utilization of stamping and rolling equipment and elimination of the need for screw machines amounted to 10 per cent.

Thus in this instance the redesign not only released screw machine capacity, eliminated the need for bar stock, saved important amounts of material and enabled surplus manufacturing capacity in the form of presses and thread rollers to be utilized but also made a reduction in cost.

Fig. 5 illustrates an unusual assembly made by spot welding at the points shown by arrows in the plan view. It represents an adapter formerly made by machining from solid bar stock. That method required 2.2 pounds of material for each unit and 8 minutes of machining time.

Now the unit is made as an assembly of two stampings. The larger stamping threaded at the two points shown is flanged out at the top and trimmed accurately to fit closely inside the second stamping, which is formed in the shape of a hexagon.

Spot Welding Joins Stampings

While the cross section shown is taken through the points of the hexagon, it is obvious that a section through the flats of the hexagon would show that the flat surfaces of both parts contact each other at the points indicated by the arrows. It is at these points that the two stampings are joined by spot welding.

The large inner stamping is made on medium size presses in a series of six operations, a seventh producing the hexagon head at the top. The outside stamping is also made from flat sheet by a set of four operations. After assembly it is only necessary to cut the threads. At the same time this redesign requires only 1.25 pounds of material, a saving of .95-pound per piece. This is almost a 50 per cent reduction in amount of material required.

Equally important is the cost reduction afforded by this design. When made as a composite stamping, the adapter ring costs only 58 per cent as much as when manufactured from the solid bar stock.

It will be noticed that in none of these examples is arc welding employed as a method of joining the stamped parts. Arc welding is avoided because of the critical alloys required in the welding rod.

Brazing and spot welding are the favored joining methods. Brazing is

(*Continued on Page* 182)

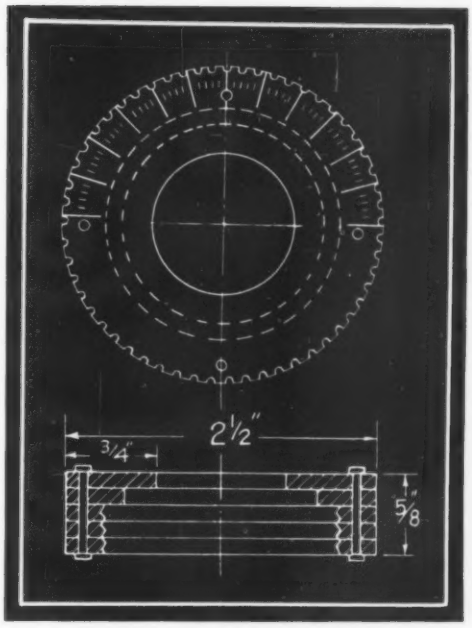


Fig. 6—Above—Handwheel made by riveting together five laminations blanked from 1/8-inch steel sheet replaces part formerly machined from solid aluminum bar stock

Fig. 7—Below—Steel sufficient for 11,500 Garand rifles is saved by making this fin locknut as a composite stamping instead of a forging

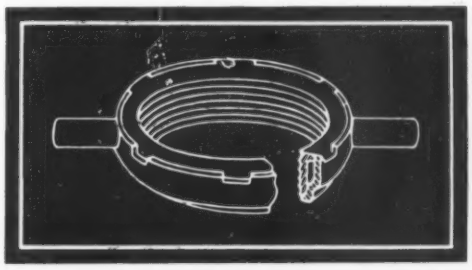
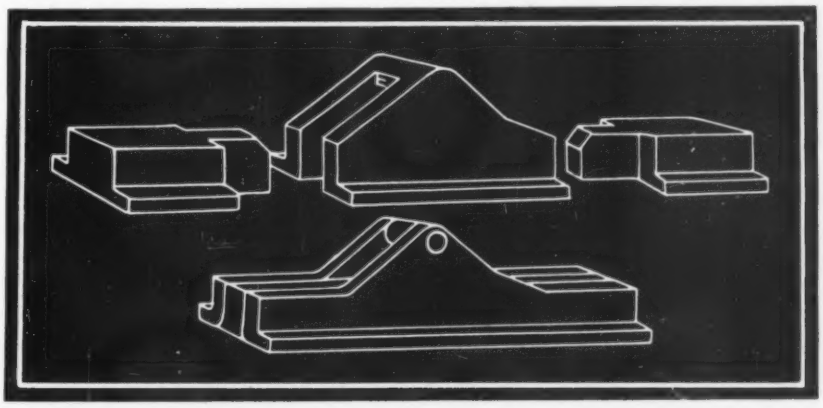
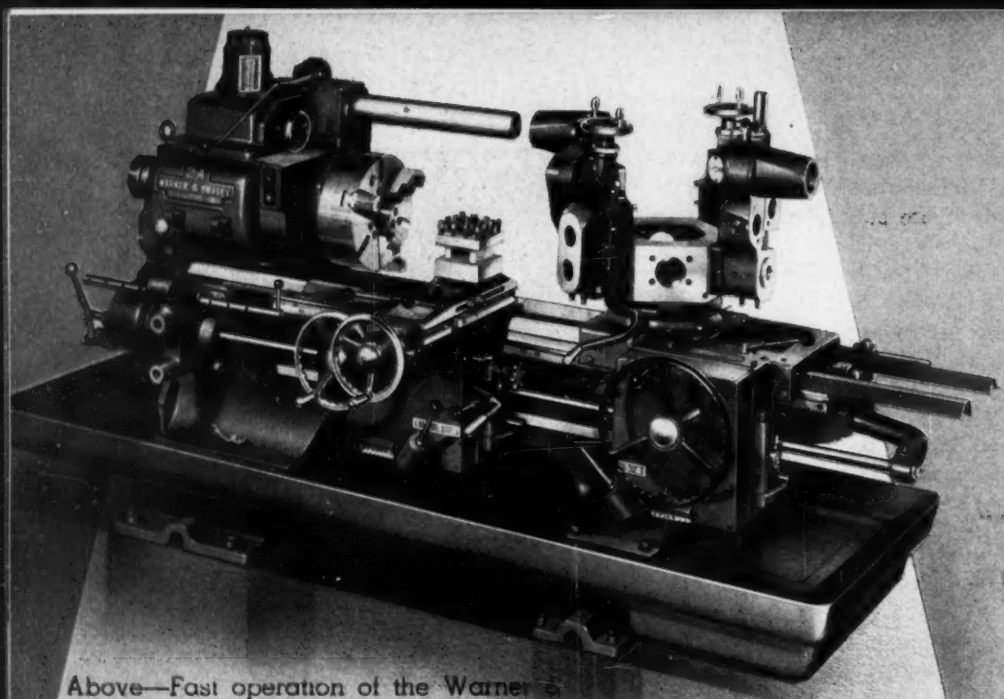


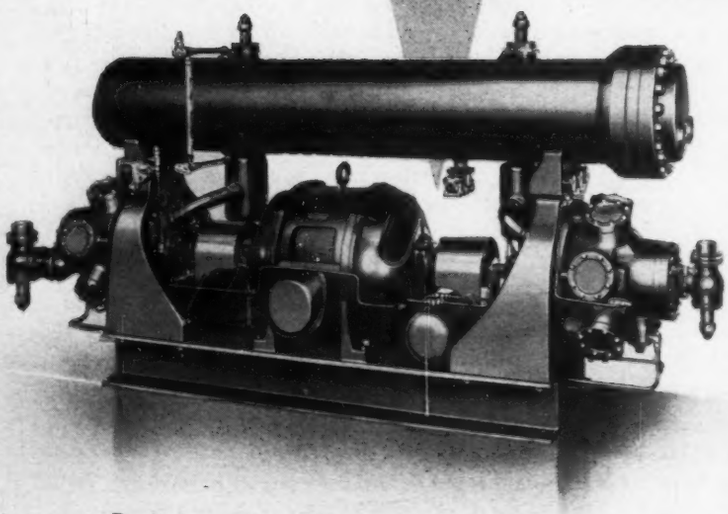
Fig. 8—Below—Upper view shows forged and machined parts formerly required for this suspension guide fitting. Lower view shows brazed assembly of stampings



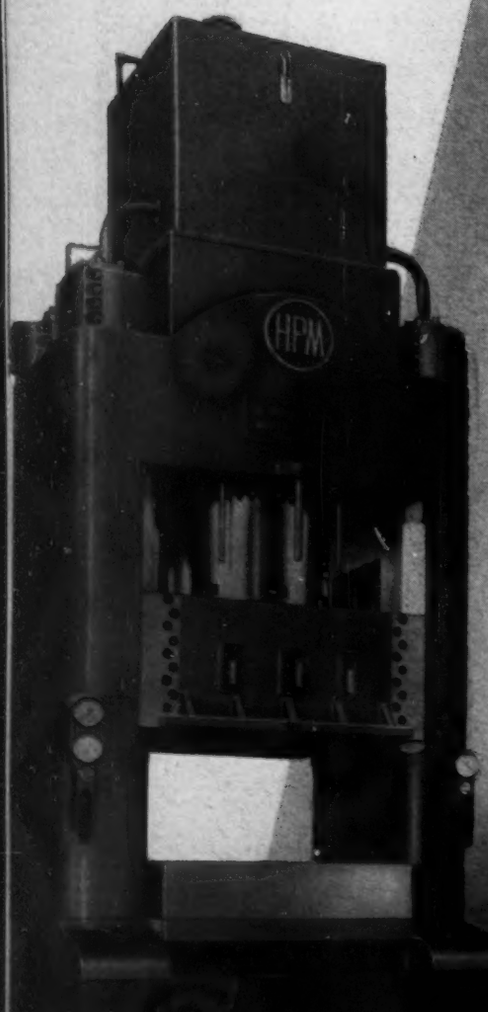


Above—Fast operation of the Warner & Swasey heavy-duty turret lathe is facilitated by the grouping of cross slide and apron controls in a concentrated zone. Special design of the square turret control eliminates the conventional through-center stud, permitting the use of an open type turret in the center of which cutters can be grouped for multiple cutting

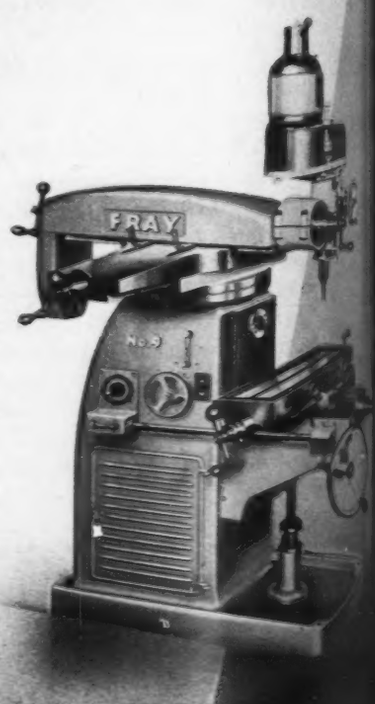
Right—Open-back frame of the 150-ton Bliss Consolidated press allows feeding strip stock either right to left or front to rear. The press can be inclined 39 degrees allowing the completed work to fall by gravity to the rear of the machine. A 15-horsepower motor mounted inside the frame operates the press through gearing

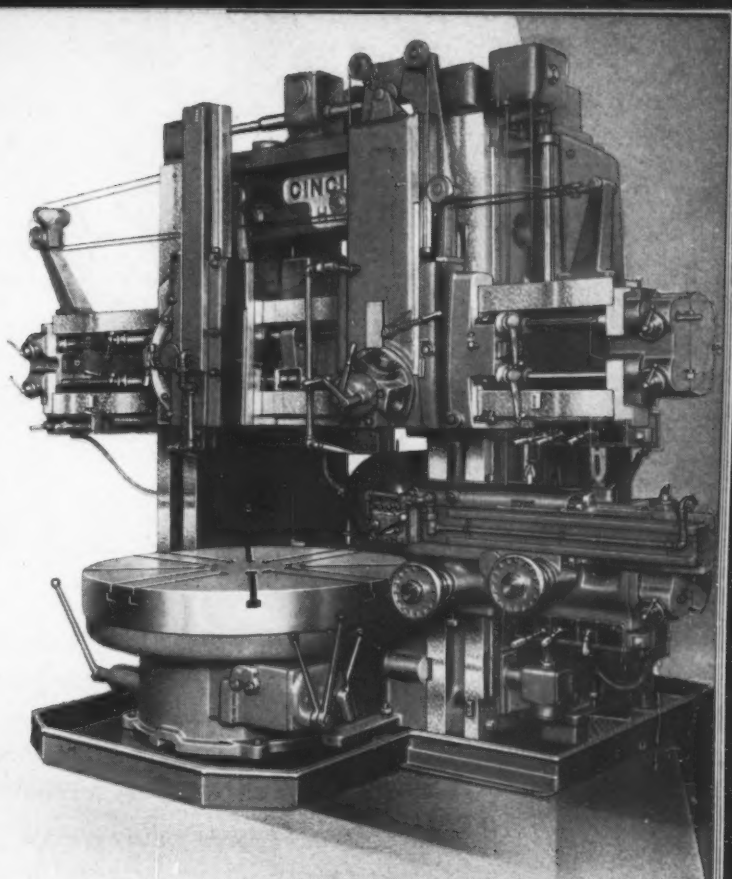


Above — Radial compressors contribute toward the compact design and freedom from vibration of the Airtemp refrigeration unit. Oil pressure from the force-feed lubrication system holds the suction valves open during unloaded operation



Left—Frame of the HPM 3500-ton deep-metal drawing press consists of a cast-steel head and bed spaced by a pair of cast uprights. Preloaded tie rods passing through each upright lock the assembly. Pushbutton controls are provided for all movements, the closed operating system effecting reversal of the ram by reversing the delivery from the pump





Right—Table of the Cincinnati Hypro boring and turning mill revolves on a large diameter antifriction bearing driven by a spiral bevel gear Bed and speed box are of one-piece construction with a double wall and reinforced by radial ribs, eliminating distortion. Drive provides sixteen mechanical speeds

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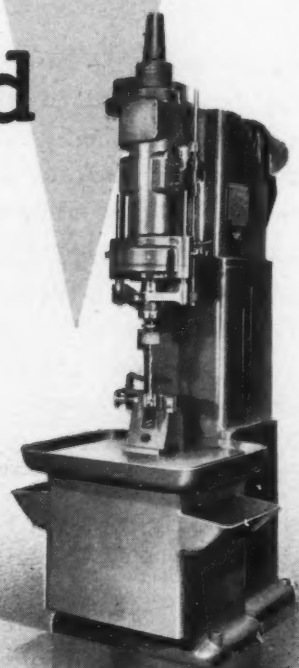
ngs, see page 196



Left—Spindle of the Detroit Tap precision tapping machine is driven at a point between the tap and lead screw, avoiding inaccuracies due to lead screw wind up. Hardened and ground lead screws operate in adjustable split bronze nuts designed for easy adjustment to eliminate backlash

Below—Equipped with four die heads and one stripper head, the Baldwin Southwark horizontal hydraulic double-acting draw press is being used for the production of 155-millimeter shell forgings. With a stroke of 11 feet the piston of this 200-ton press is supported by a crosshead having adjustable shoes on the two press columns

t—Milling, drilling or boring erations can be performed at y angle by the Fray horizontal d vertical milling machine ngitudinal operations are done traversing the ram on the turslide, crosswise by operating ram in its saddle. For horintal milling the turret head is ersed and the vertical attach ment swung out of the way

MACHINE DESIGN *Editorial*

The Designer Comes Through!

A YEAR ago this page emphasized the pressing challenge to design. During that year there have been many times when the call seemed to go unanswered. More than that, with each setback in battle numerous critics have bemoaned the apparent tardiness and lack of ingenuity on the part of American engineers.

Could there be any more effective answer to such critics than the war news at the present time? On every front, at this writing, the forces of the United Nations are pressing forward. Though credit is due primarily—and always will be—to the bravery and self-sacrifice of those in the front lines, the war equipment designed and produced in this country is daily playing a more and more effective role.

Designers of planes, tanks, ships, guns (one specific type of which is discussed in the leading article in this issue) and of the machines for producing them, should feel justly proud of their achievements. Mistakes admittedly have been made, but that these have in the main been overcome is now being proved beyond question.

What of the more severe tests that lie ahead? What of the far greater sacrifices that are inevitable in the fighting that still remains? And what of the advances in design and production that the Axis nations undoubtedly are calling for with all the power they still have?

It would be foolhardy for us to believe that the efforts of German engineers, in particular, can now be discounted or that the tide of war, though now in our favor, will not flow against us again. Should we not from this time forward—if we have failed to do so thus far—think not only of the freedoms for which we are fighting, but of the loss of lives that will be suffered in achieving them? Only thus can those behind the lines see the war in its true perspective and do everything humanly possible to help the fighting services on their way to early and conclusive victory.

L. E. Jerry

Selecting Helical and Worm Gearing

By R. D. Douglass* and J. M. Dunford†

BECAUSE the selection of right angle helical gears involves considerable trial and error calculations, the accompanying alignment charts have been prepared to enable the designer to obtain a satisfactory solution in a shorter time than is required by the usual procedures.

Design of such gears involves the solution of an equation which may take the following form:

$$\frac{2P_{dn}C}{N_d}=\frac{1}{\sin\alpha_f}+\frac{R}{\cos\alpha_f} \quad \ldots\ldots (1)$$

where P_{dn}=normal diametral pitch, C=center distance in inches, N_d=number of teeth on the driving gear, α_f=helix angle of teeth on following gear, that is, the angle between the tooth elements and the axis, R=velocity ratio=rpm of driver/rpm of follower.

The five variables are all more or less dependent on each other. The diametral pitch and number of teeth must be integers. Center distance is often fixed or limited to a small range, and diametral pitch may be limited by the cutters available. Nevertheless, there can be a large number of solutions to almost any problem arising in the design of such gears. If the condition be imposed at the outset that a minimum center distance is desired for a given diametral pitch and number of teeth, a relation can be established between R and α_f by differentiating the original equation with respect to α_f and setting equal to zero:

$$\frac{\cos\alpha_f}{\sin^2\alpha_f}-\frac{R\sin\alpha_f}{\cos^2\alpha_f}=0$$

from which

$$R_{mc}=\cot^3\alpha_f$$

where R_{mc} is the velocity ratio for minimum center distance. Writing

$$\cot\alpha_f=R_{mc}^{1/3}$$

then

$$1+\cot^2\alpha_f=1+R_{mc}^{2/3}$$

and

$$\csc\alpha_f=(1+R_{mc}^{2/3})^{1/2}=\frac{1}{\sin\alpha_f}$$

Substituting in Equation 1:

$$\frac{2P_{dn}C}{N_d}=(1+R_{mc}^{2/3})^{1/2}+\frac{R_{mc}(1+R_{mc}^{2/3})^{1/2}}{R_{mc}^{1/3}}$$

$$=(1+R_{mc}^{2/3})^{3/2}$$

$$=K \quad \ldots\ldots (2)$$

A double alignment chart constructed for Equation 2 is given in *Fig.* 1. The scales are plotted logarithmically and the K-scale is calibrated with the corresponding values of R_{mc}.

If three values are fixed, a unique solution is obtained for the fourth. A change in center distance will cause a corresponding change in the ratio for which that distance is a minimum, as well as the helix angle corresponding to that ratio. Value of α_f is obtained from the horizontal scale at the bottom of *Fig.* 1.

If the center distance will not admit of any change, the ratio can be varied through small amounts by a change in the helix angle alone. The new helix angle corresponding to a small change in R from the value for minimum center distance can be found from the double-alignment chart of *Fig.* 2, constructed for the equation:

$$K=\frac{1}{\sin\alpha_f}+\frac{R}{\cos\alpha_f} \quad \ldots\ldots (3)$$

which results from combining Equations 1 and 2. The K-scale is calibrated in values of R_{mc} as before. This value of R_{mc} can always be obtained from *Fig.* 1 for a given value of P_{dn}, C, and N_d, and the helix angle can be corrected by *Fig.* 2 so that R will meet the requirements of the problem. It is worth noting that if the desired R is equal to R_{mc} there is but one solution, for the cutting line on *Fig.* 2 will be tangent to the curve. The point of tangency can be checked with that given on the scale at the bottom of *Fig.* 1. If R is greater than R_{mc} the solution will be impossible. If R is less than R_{mc} there will be two choices of α_f and good practice usually dictates that the smaller be used.

Since the ratio scale has been carried from 1 to 100 in *Fig.* 1, this chart covers the whole range from identical

*Professor of Mathematics, Massachusetts Institute of Technology.
†Lieutenant, U.S.N.

gears up to worm gearing. Since an extension of ratios in *Fig.* 2 beyond a ratio of 10 would make the angle scale too small for easy reading the correction of angle cannot be applied to ratios higher than 10. Since greater latitude in ratio or center distance is usually allowed in the higher ratios, it is believed that the range of values used will solve the great majority of right angle helical and worm gearing problems.

Throughout this discussion the smaller gear is assumed to be the driver and the ratios therefore are all greater than 1. In case the opposite is true, the problem can be solved readily by taking the smaller gear as the driver.

EXAMPLE 1: It is desired to fit a pair of right angle helical gears having a ratio of 6 to 1, a diametral pitch of 8, and 10 teeth on driver into a center distance of 6 inches. If the diametral pitch, driver teeth, and center distance are applied to *Fig.* 1, the ratio for minimum center distance is 6.7 as against 6, the value desired. If these two values are applied to *Fig.* 2, the helix angle is found to be 16° 50′ which gives the solution of the problem.

EXAMPLE 2: It is desired to design a pair of right-angle helical gears to give a ratio of 1.6 and to fit in a center distance which may vary between 4½ and 4⅝ inches, the gears to have a diametral pitch of 12. A trial solution may be made for N_d by using $C = 4\frac{1}{2}$ inches and the number of teeth is found to be between 29 and 30. 30 is selected since 48 teeth for the follower will then give the required ratio. Using $N_d = 30$, the exact center distance is found to be 4.55 inches, and the value of α_f corresponding to an R of 1.6 from *Fig.* 1 is 40° 32′.

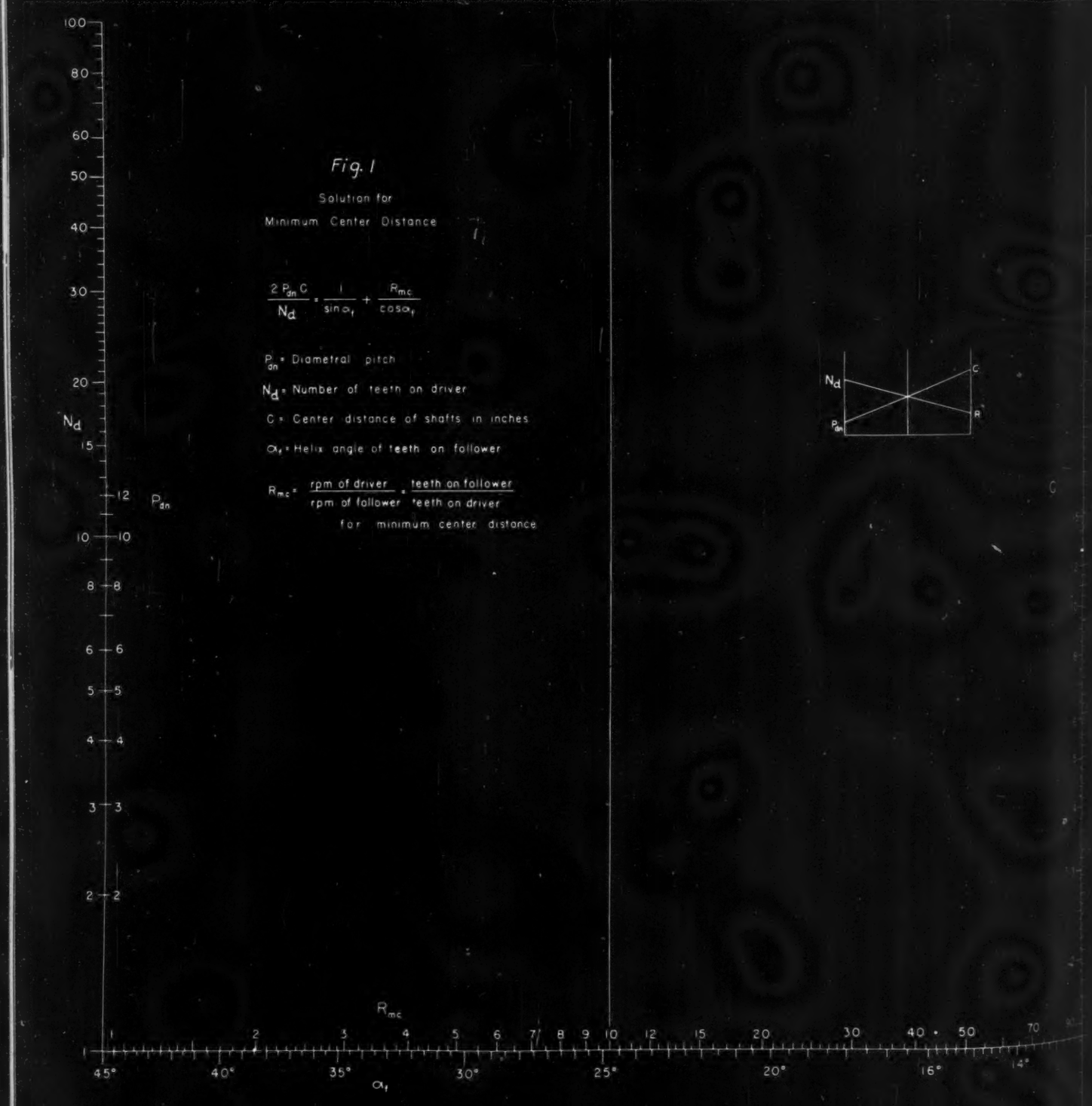


Fig. 1
Solution for
Minimum Center Distance
$\frac{2 P_{dn} C}{N_d} = \frac{1}{\sin \alpha_f} + \frac{R_{mc}}{\cos \alpha_f}$
P_{dn} = Diametral pitch
N_d = Number of teeth on driver
C = Center distance of shafts in inches
α_f = Helix angle of teeth on follower
$R_{mc} = \frac{\text{rpm of driver}}{\text{rpm of follower}} = \frac{\text{teeth on follower}}{\text{teeth on driver}}$
for minimum center distance
N_d
P_{dn}
R_{mc}
α_f
C
R

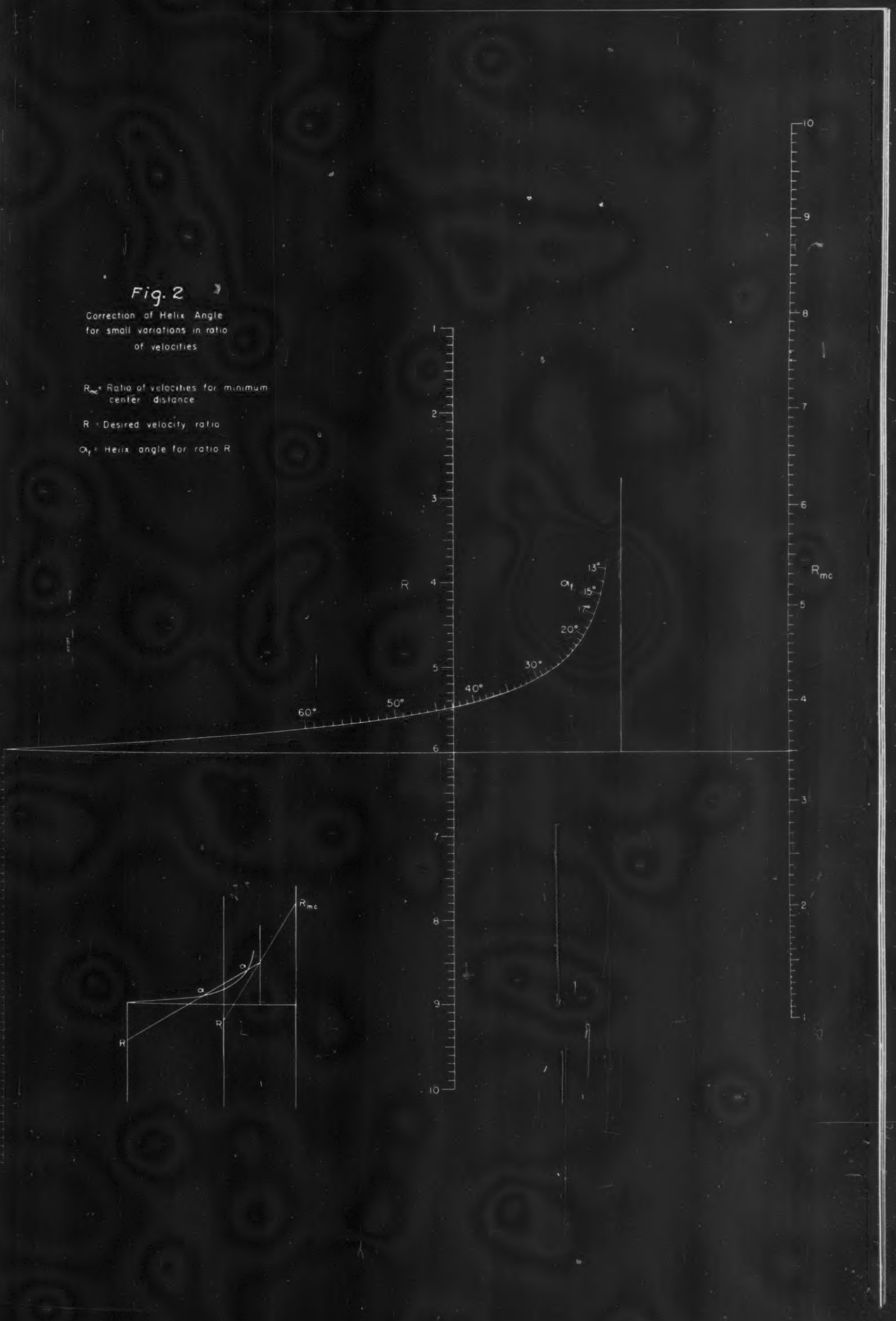


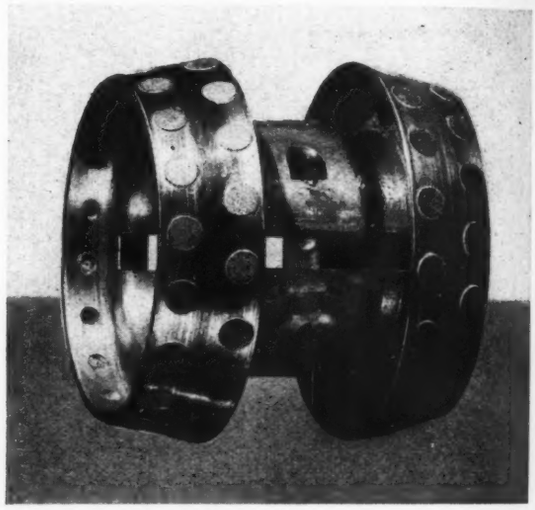
Fig. 2
Correction of Helix Angle for small variations in ratio of velocities
R_{mc} = Ratio of velocities for minimum center distance
R = Desired velocity ratio
α_1 = Helix angle for ratio R
R
α_1
13°
15°
17°
20°
30°
40°
50°
60°
R_{mc}
1
2
3
4
5
6
7
8
9
10
R
R_{mc}
α
α_1
R'
L

Applications

of Engineering Parts and Materials

Replaces Flax for Mechanical Packings

FOR mechanical sealing against the entrance or escape of water, brine, oil, or other fluids, a special form of Dupont rayon is replacing imported long line flax which is now scarce because of wartime shipping difficulties. The rayon tow is braided and impregnated with lubricants by mechanical packing manufacturers. Usually the finished packing is square in cross-section and is installed in the stuffing box in a spiral coil, as shown below. The smooth unbroken filaments of rayon show very low abrasion on the metal shafts they enclose.



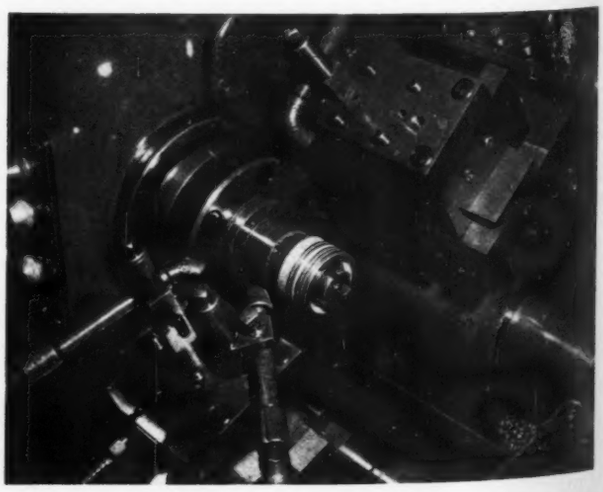
Inserts Improve Clutch Operation

WEAR in the clutch body and friction drive rings of automatic screw machines may be compensated for by adjustment but, as the friction rings are adjusted out, wear shows up in the threads. Micarta inserts in the friction face of the clutch body, as shown above, allow the friction rings to be adjusted back into the friction backs and does away with looseness in the threads. This contributes to smooth and quiet operation, and it has been noted that less tension is required to drive the spindle. Wear appears to be negligible.

Expanding Arbor Uses Compressed Air

COMPRESSED air operates the expanding arbor shown at right holding a grooved cylinder for turning on a lathe. The operator slips the part to be machined over the arbor and presses a button admitting air from the factory line which expands the arbor and holds the piece. When the job is finished the operator again presses the button and the part is released. Thus much hand work of fastening, adjusting and unfastening is eliminated. War plants use these expanding arbors to cut production time and reduce worker fatigue.

Photo, courtesy Compressed Air Institute



How to make your SLEEVE TYPE BEARINGS *last longer*

Most bearing failures are due either to improper fit or neglect. While manufacturers engaged in producing war material can still secure replacements with a minimum of delay, it is not only good management but also a form of patriotism to make every bearing deliver its full measure of power and efficiency. Bronze sleeve type bearings contain three very essential metals . . . copper, tin and lead. Help conserve these precious metals by following these instructions:

Inspect . . .

Adopt a regular period of inspection. In machinery that operates constantly the bearings should be checked each day. All other applications at least once a week. Make certain that bearings are in perfect alignment to prevent excess wear.

Clean . . .

Foreign matter, particularly of a gritty or abrasive nature is the greatest menace to bearings. By keeping the surroundings clean, you can prevent early bearing deterioration. A few minutes spent in cleaning up all applications will pay big dividends in increased bearing life and efficiency.

Lubricate . . .

Lubrication is the life blood of every motive unit. Start now to adopt a regular plan of lubrication for every bearing. Make sure you are using the right type of lubricant, the right grade and that it is clean.

Replace . . .

If failure is inevitable, order in advance. Replace all worn bearings *before* they actually fail. Remember that bearing performance and bearing life is the true gauge of quality . . . not purchase price.

Write for a copy of our new catalogue. It lists and describes the most complete stock sleeve bearing service on the market. Every item is of the highest quality possible. Distributors in every industrial center are ready to serve you.

From Stock

GENERAL PURPOSE BEARINGS

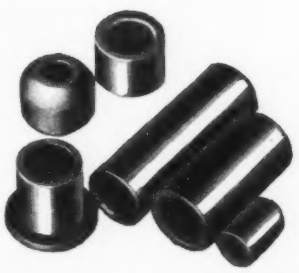
Cast Bronze, over 850 stock sizes, machined, ready for assembly.

ELECTRIC MOTOR BEARINGS

250 individual types. Correct in design, alloy and tolerances.

Ledaloyl
SELF-LUBRICATING BRONZE BEARINGS

Powder metallurgy at its best. Contain up to 35% oil by volume.



JOHNSON BRONZE COMPANY

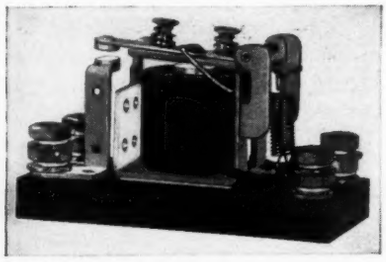
Sleeve BEARING HEADQUARTERS

525 SOUTH MILL STREET • NEW CASTLE, PA.

New PARTS AND MATERIALS

Relay for Aircraft Circuits

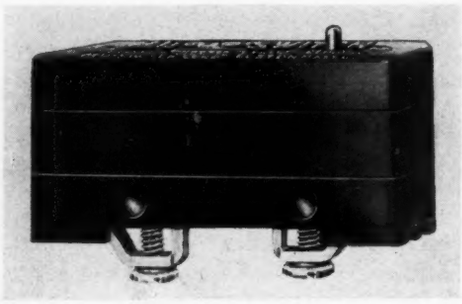
DESIGNED for remote control of aircraft electrical circuits, the new B-2-A relay of Guardian Electric Mfg. Co., Dept. B-2-A, 1601 West Walnut street, Chicago, has been built to U. S. Army Air Force specifications. The unit has a contact rating of 25 amperes continuous and 100 amperes surge at 25 volts direct current. It has single



throw, normally open contacts. Weight is 6 ounces. Acceleration and vibration resistance are over ten times gravity. Metal parts are heavily plated to withstand a 200-hour salt spray test. While the relay has been designed primarily for the aircraft industry, it also has numerous applications in other fields.

Switch for Direct Current

COMPACT, precision made and sensitive snap-action type "DX" switch has been offered by Mu-Switch Corp., Canton, Mass., to make or break moderate direct-current loads with extremely slight travel of the actuating button and relatively light operating pressure. Special contact alloys insure maximum freedom from



sticking. A powerful magnet is so located that the destructive direct-current arc is blown out and burning of contacts is held to a minimum. Construction of the new switch is similar to the company's heavy-duty "D" switch but is smaller and lighter. Housing is cold-molded of a special heat-resisting composition treated for minimum moisture absorption. Inserts are molded-in. Positive action, long life and safe current-carrying capacity within the rated load is assured by the reverse cross-action spring principle. Spring material is heat-treated beryllium copper. The switch can handle up to 30 amperes of noninductive load at 28 volts at altitudes to 45,000 feet. Rating at 125 and 250 volts is one kilowatt, noninductive load. It can be supplied with many styles of actuators, brackets and housings. Operating characteristics can be modified to meet unusual operating requirements.

Fume and Watertight Grommet

FUMETIGHT and watertight grommets for air, oil and hydraulic lines, electrical cables, flexible remote control casings, etc., announced by Arens Controls Inc., 2253 South Halsted street, Chicago, eliminate many quick-disconnect and firewall or bulkhead fittings. Slipping over a line, cable or tube, and fitting snugly against the wall, this grommet, called the Dura-Grom, consists of only two parts: An oil-resisting synthetic rubber disk and a cadmium-plated steel cup retainer for securely attaching grommet to wall. The packing member is an oil-resisting, synthetic-rubber block which permits considerable bearing surface. Retainer cup has an opening large enough to slip over a line or tube including end fittings. Retainer is a steel stamping, cadmium plated to resist corrosion. Multiple lines can be supported by special grommets, having individual openings in the rubber disk for each line. Bolts or screws are used to hold the Dura-Grom snugly against supporting wall.

Zinc-Plated Steel Offered

ELECTROPLATED zinc on steel—a war-minded metal—has been added by American Nickeloid Co., Peru, Ill., to its line of plated metals. It is a substitute for pure nickel, tin, chromium, aluminum, or stainless steel. Zinc-plated steel provides a protective coating to the base metal making it highly resistant to corrosion

Today's Destination:
BATTLE FRONTS

Tomorrow's:
INDUSTRIAL U. S. A.

TENUAL ALUMINUM CASTINGS are proving their worth on far-flung battle fronts in planes . . . tanks . . . ships. And our castings will "come through" under all conditions because of our ability to meet the most rigid specifications of the armed service with speed and quantity production. This will be your guarantee of receiving quality sand and permanent mold aluminum castings when our shipping tags can again read: Destination U. S. A.

Illustration shows careful water pressure testing of an important aircraft aluminum casting

TENUAL

FOR VICTORY
BUY UNITED STATES WAR BONDS AND STAMPS

THE *National* BRONZE & ALUMINUM FOUNDRY CO.
CLEVELAND, OHIO
NEW YORK, 111 Broadway • CHICAGO, 188 W. Randolph • DETROIT, Stephenson Bldg. • LOS ANGELES, 405 S. Hill
MAKERS OF QUALITY SAND AND PERMANENT MOLD ALUMINUM CASTINGS

Screw Machine Job?

NO-

A FORGING BY PHOENIX

Formerly this welding tip was made in a screw machine. The product was good but the production costs were excessive. Waste of material and necessary machining made the operation unduly expensive.

Then Phoenix took over. Phoenix engineers developed a method of fabrication which greatly reduced the amount of material required and completely eliminated all machining. Naturally the cost of the finished piece was materially reduced.

FORGINGS by PHOENIX

Today, these welding tips — Forged by Phoenix — are daily demonstrating the effectiveness and efficiency of this modern method of fabrication.

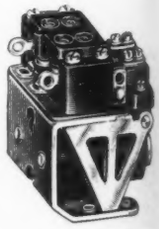
Conservation of material and labor is of vital importance these days. Perhaps you have a problem in which these same savings can be affected. If so, the advice and suggestions of our engineers will not obligate you in any way, so why not write Phoenix — today?

PHOENIX MANUFACTURING COMPANY
Catasauqua, Pa.
Phoenix Products Mean Quality

and rust. It can be bent, stamped, formed, drawn, soldered and spot welded to meet most requirements, and is supplied in uniformly prefinished flat sheets only in sizes up to 36x96 inches, in a full range of gages and tempers, in polished, unpolished and satin finishes. The thickness of the coating, which is guaranteed, can be varied to meet specific requirements.

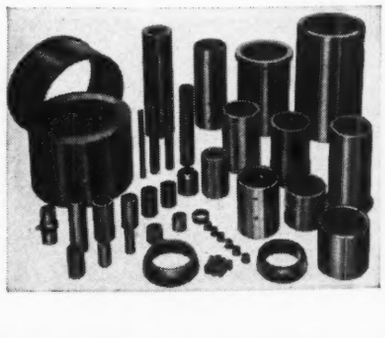
Specially Built Aircraft Relays

TO MEET the severe requirements of aircraft, G-M Laboratories Inc., 4314 North Knox avenue, Chicago, is offering its new Type 27 relay. Electrical characteristics of the relays can be varied over a wide range to suit requirements of different applications. For instance, one relay built by the company to satisfy the requirements of a specific customer meets the following specifications: Vibration and acceleration, 15g; altitude, 40,000 feet; contact pressure for double-make, double-break contacts, 50 grams; contact capacity at 30 volts direct current, 20 amperes (inrush 100 amperes); 200-hour salt-spray test; pick-up, at 20 degrees Cent., 50 volts (.36 watt); nominal coil voltage, 14 volts direct current; coil wattage at 14 volts direct current at 20 degrees Cent., 2.8 watts; temperature range, —40 to +90 degrees Cent. Dimensions are 1½ x 1⅝ x 1⅞ inches. Weight is 5 ounces. The box frame construction of the relays provides compactness, strength and sturdiness. Contacts are mounted in an open-sided phenolic box for protection.



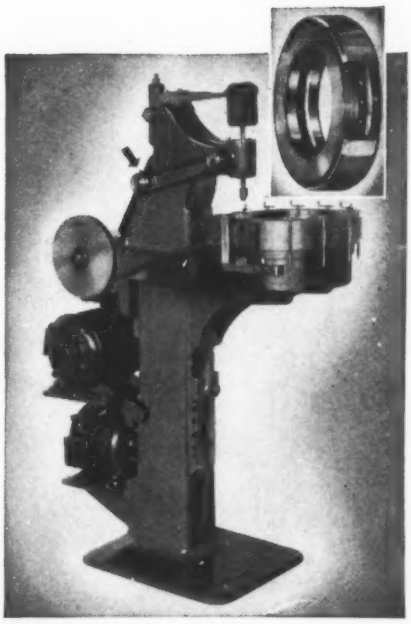
Molded Fabric Bearings

THROUGH the use of oil-lubricated, nonmetallic molded bearings, developed by Gatke Corp., 228 North La Salle street, Chicago, the shortage of critical bearing metals is being overcome. Known as Lubritex bearings, they are distinctly different from the company's Hydrotex (water-lubricated) and Grafitex (self-lubricated) bearings, in that they are made of various material combinations developed especially to meet all types of service conditions using grease or oil lubrication. The new bearings replace conventional bearings with satisfactory results, and withstand impact loads too great for metal bearings. Lubrication is much less critical, journals not being scored even if lubrication fails for limited periods.

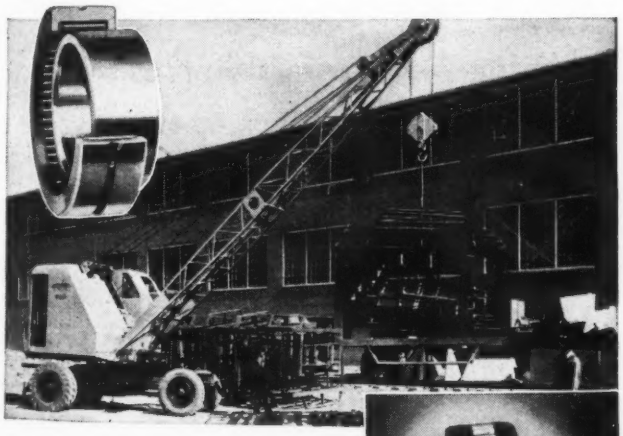


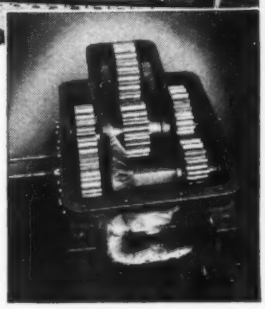
IN THE NEWS
WITH BANTAM BEARINGS

STRIKING POWER! Somewhere in the Pacific, U.S. Aircraft Carriers are seeking the enemy, looking for the chance to "dish-it-out." Back in South Bend, Indiana, other men and women—fathers, uncles, sisters, friends of the boys on the fighting fronts—are "dishing-it-out" too. That's why everyone of us at Bantam is proud of our third award of merit, the Army-Navy E flag with Two Stars. We're proud too, to have Bantam Bearings serving on nearly every type of fighting ship in the U. S. Navy.

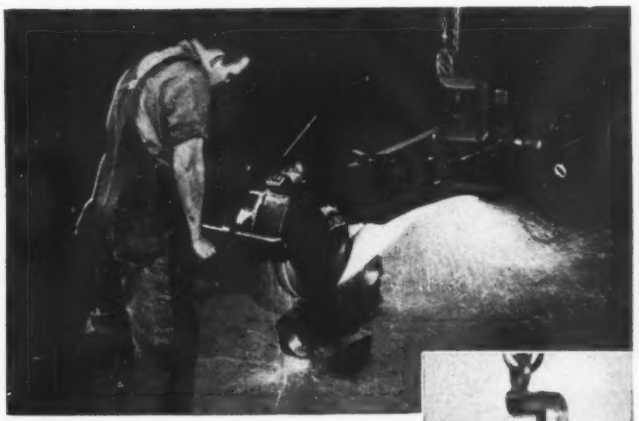


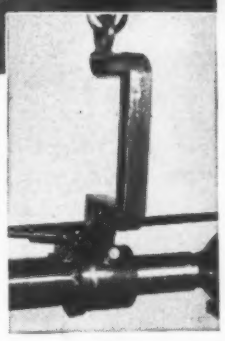
1800 TIMES PER HOUR *a thrust load* is exerted on this Rotary Hammer-type Riveter designed and built by The Grant Mfg. & Machine Co. Bantam Ball Thrust Bearings are used to carry the thrust load between the mainshaft bearing and inner clutch plate as well as the thrust of the mainshaft at point shown in the photo between the spindle pulley and the frame. Because Bantam's line includes all major types of anti-friction bearings Bantam's engineers are in a position to give experienced help and counsel in the design and selection of bearings for any type of job.





THIS SIX-TON "MOBILCRANE" does the job whenever and *wherever* needed. Built by the Osgood Company it operates and travels on a single power unit. In the design of the wheel drive power transmission, shown in close-up, Bantam Quill Bearings support one end of the transmission shafts which operate at 290 to 660 R.P.M. under heavy load—especially when operating in low gear. This interesting application utilizes the compact design and high capacity of Bantam's Quill Bearing. Additional information will be found in our Catalog. Write for your copy of Bulletin B-104.





SWING IT! For grinding large castings, take grinder to the job. That is an outstanding advantage of the swing frame grinder manufactured by the Vonnegut Moulder Corporation. And the "swing frame" (see inset) which holds the grinder chassis turns on a Bantam Quill Bearing to insure freedom of movement and ease of control in manual operation. This is another application where Bantam Quill Bearings are helping industry-at-war "beat the promise."

IF YOU'RE IN WAR WORK and need anti-friction bearings for any type of job TURN TO BANTAM. The Bantam line includes every major type of bearing—straight roller, tapered roller, needle and ball. Our engineers will be glad to work with yours in meeting today's needs and planning tomorrow's designs. Call us if we may be of help on any type of anti-friction bearing problem.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

...NOW STEPPING UP WAR DELIVERIES

1. They save the worker's time

Each nut is a self-contained easy-to-handle unit that goes on fast . . . and its self-locking action is immediate and automatic.

2. They eliminate the dangers of careless assembly

The locking element is built into the nut . . . no pins, wires, washers, or shims that can be forgotten or incorrectly applied.

3. They reduce inspection needs

With less operations and less parts to be checked . . . there's another important saving in man-hours.

There are more Elastic Stop Nuts on America's airplanes, tanks, guns, Naval vessels, and production equipment, than all other lock nuts combined.

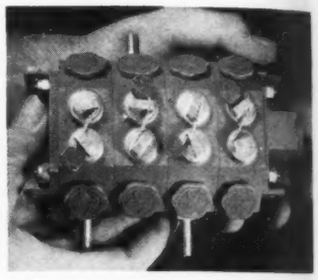
» Write for folder explaining fully the Elastic Stop principle

ELASTIC STOP NUT CORPORATION
2326 VAUXHALL ROAD • UNION, NEW JERSEY

The bearings are available for many applications and are molded to finished dimensions.

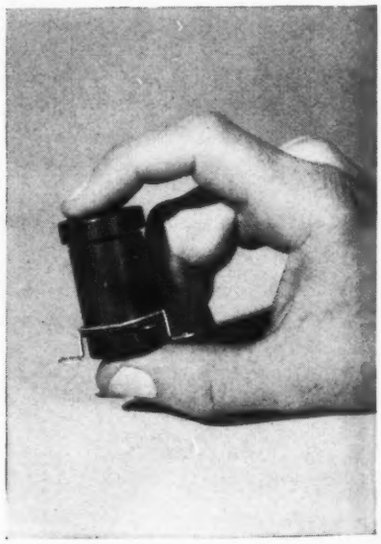
Valves for Hydraulic Systems

IN AIRCRAFT hydraulic equipment a new development is that of the "stacking midget" valve announced by Adel Precision Products Corp., Burbank, Calif. It is designed to permit installation of multiple hydraulic controls in limited space such as cockpit control panels. The new valve possesses the same weight and space saving advantages as the company's four-way selector valve—that is, it is 72 per cent smaller and 76 per cent lighter in weight than former models. It measures only 5-31/32 x 3-3/16 x 2-7/16 inches overall, and weighs 2.9 pounds. Individual valve assemblies may be replaced or repaired by breaking only the two cylinder lines affected. Fitting as a single body, any number of units may be clamped together by means of through bolts and end plates which also serve as flanges. Symmetrical design permits turning end-for-end to meet desired shaft arrangements. An integral stop located on the camshaft prevents overtravel.



Relay for Aircraft Applications

ANNOUNCED by General Electric Co., Schenectady, a new dust-tight relay has been especially designed for aircraft applications requiring high current-carrying capacity without any sacrifice of compactness and weight.



The relay is a solenoid-operated device with normally open contacts rated at 10 amperes direct current, which will make or break 30 amperes at altitudes up to 40,000 feet. Coil, contacts and plunger are enclosed in a dust-

SEGREGATED *Scrap...*

is your link to VICTORY!

Scrap salvage is a vital factor in the war effort. To be fully effective a scrap program must include methods for segregating and conserving critical alloying elements so urgently needed in the construction of tanks, guns, ships and planes.

Ferrous and non-ferrous metal scrap should be collected in separate containers at the machine where they are generated. Each class of high-speed tool steel and each type of constructional alloy steel should likewise be kept separate so that the alloy content can be returned to service.

Remember, — alloy scrap which is segregated, classified and labeled according to type and composition is a vitally important commodity today—and urgently needed to augment primary supplies of Nickel, molybdenum, tungsten, etc.

The metallurgical experience of our technical staff is available to aid you in these and other phases of metal salvage.

KEEP SCRAP MOVING INTO WAR PRODUCTION!

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

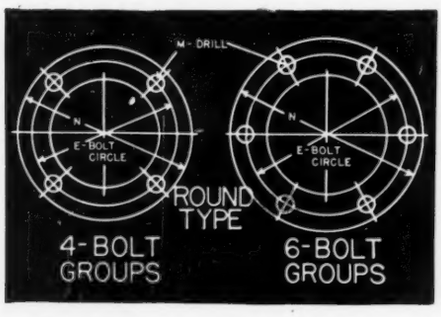
Conserve Time and Materials

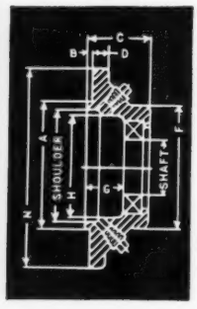
Low unit cost in small or large quantities, the saving of costly "nuisance" set ups, reduction in designing, drafting, detailing and checking time as well as the entire elimination of the costs of patterns, jigs, fixtures, gages, etc.—these are the chief advantages of R-S Standard Bearing Covers.

R-S STANDARD BEARING COVERS

Order by number from stock. Bulletin No. 11-C contains full particulars, dimensions and detailed drawings. Write for your copy today.

Bearing Appliance Division
R-S PRODUCTS CORPORATION
112 Berkley Street • Philadelphia, Pa.





SERIES 45—OPEN—ROUND—MEDIUM DEPTH—FOR OIL SEAL

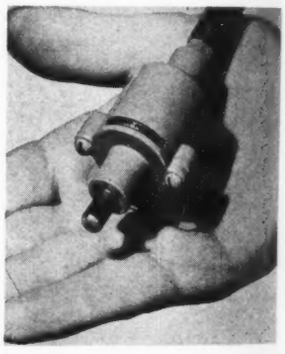
Group	Part No.	A O.D. of Bearing	B	C	D	E	F	G	H	M	N	No. & Size Bolts
9	45- 9	2.0472-2.2500	1/8	1 1/4	5/16	3	2 1/16	1 1/16	1 1/16	13/32	3 3/4	4-3/8
10	45-10	2.3125-2.5000	"	1 3/8	"	3 1/4	2 1/4	3/4	1 5/16	"	4	"
11	45-11	2.5625-2.7500	"	1 7/16	"	3 1/2	2 1/2	1 5/16	2 1/8	"	4 1/4	"
12	45-12	2.8125-3.0312	"	1 1/2	3/8	3 3/4	2 5/8	7/8	2 3/8	"	4 1/2	"
14	45-14	3.1250-3.5000	"	1 5/8	"	4 1/4	3	1 5/16	2 3/8	"	5	"
15	45-15	3.5433-3.7500	"	1 13/16	"	4 1/2	3 1/2	1 1/16	3 1/8	"	5 1/4	"
16	45-16	3.8125-4.0000	5/16	1 3/4	"	5	3 3/4	1 1/8	3 1/4	17/32	6	4-1/2
17	45-17	4.1250-4.2500	"	1 7/8	"	5 1/4	4	1 1/4	3 1/2	"	6 1/4	"
18	45-18	4.3307-4.4375	"	2	7/16	5 1/2	4 1/8	1 3/8	3 5/8	"	6 1/2	"
19	45-19	4.7244-4.7812	"	2 1/4	"	5 3/4	4 5/8	1 1/2	4 1/8	"	6 3/4	6-1/2
20	45-20	4.8750-5.1181	"	"	"	6	4 3/4	"	4 1/8	"	7	"
22	45-22	5.3447-5.5130	"	"	"	6 1/2	5 1/4	"	4 5/8	"	7 1/2	"
24	45-24	5.8437-6.0000	1/4	2 5/16	"	7	5 3/4	1 5/16	5 1/8	"	8	"
25	45-25	6.1875-6.2992	"	"	1/2	7 1/2	5 7/8	"	5 1/4	21/32	8 3/4	6-3/8

R-S
STANDARD BEARING COVERS
14 Sizes . . . 12 Types . . . 13 Depths

tight housing, and the unit is corrosionproof. Furnished in a single-pole, single-circuit form with normally-open contacts or in a single-pole, two-circuit form with one normally-open and one-normally closed contact, the relay has met requirements of a 200-hour salt-spray test as stipulated by various government agencies. The operating coil can be furnished for either 12 or 24-volt direct-current operation. Mounted in any position on a metal or nonmetallic base, the relay is designed for use in an ambient temperature range from 95 Cent. to −40 Cent., and will withstand 95 per cent humidity at 75 Cent. on 48-hour tests. When relay is energized or de-energized, contacts will remain in open or closed positic• without chattering, even when subject to mechanical frequencies of from 5 to 55 cycles per second at 1/32-inch amplitude (1/16-inch total travel) applied in any direction.

Miniature Air Clamps Announced

ALTHOUGH the new miniature air clamp of Mead Specialties Co., 15 South Market street, Department M-21, Chicago, has been expressly designed for the aircraft industry, it is highly useful in many fields. This tiny clamp delivers 80 pounds pressure on a line pressure of 100 pounds. Stroke of the ram is 5/8-inch. An internal spring withdraws the ram when air is exhausted from the cylinder by the control valve. Action is instantaneous. All air clamps in any set-up can be operated by a single master valve. "Lock-up" and "release" of assemblies is instantaneous which saves time even on small and simple assemblies. Being small the clamp can be installed in cramped corners difficult to reach with more bulky clamps. Special adjustments are unnecessary since clamp ram holds with equal pressure at any point along its stroke. Any desired group of these clamps can be controlled independently of any other groups in a given assembly. Many types of light bench assembly jobs and drilling operations can be facilitated by the use of these clamps actuated by foot control valves.

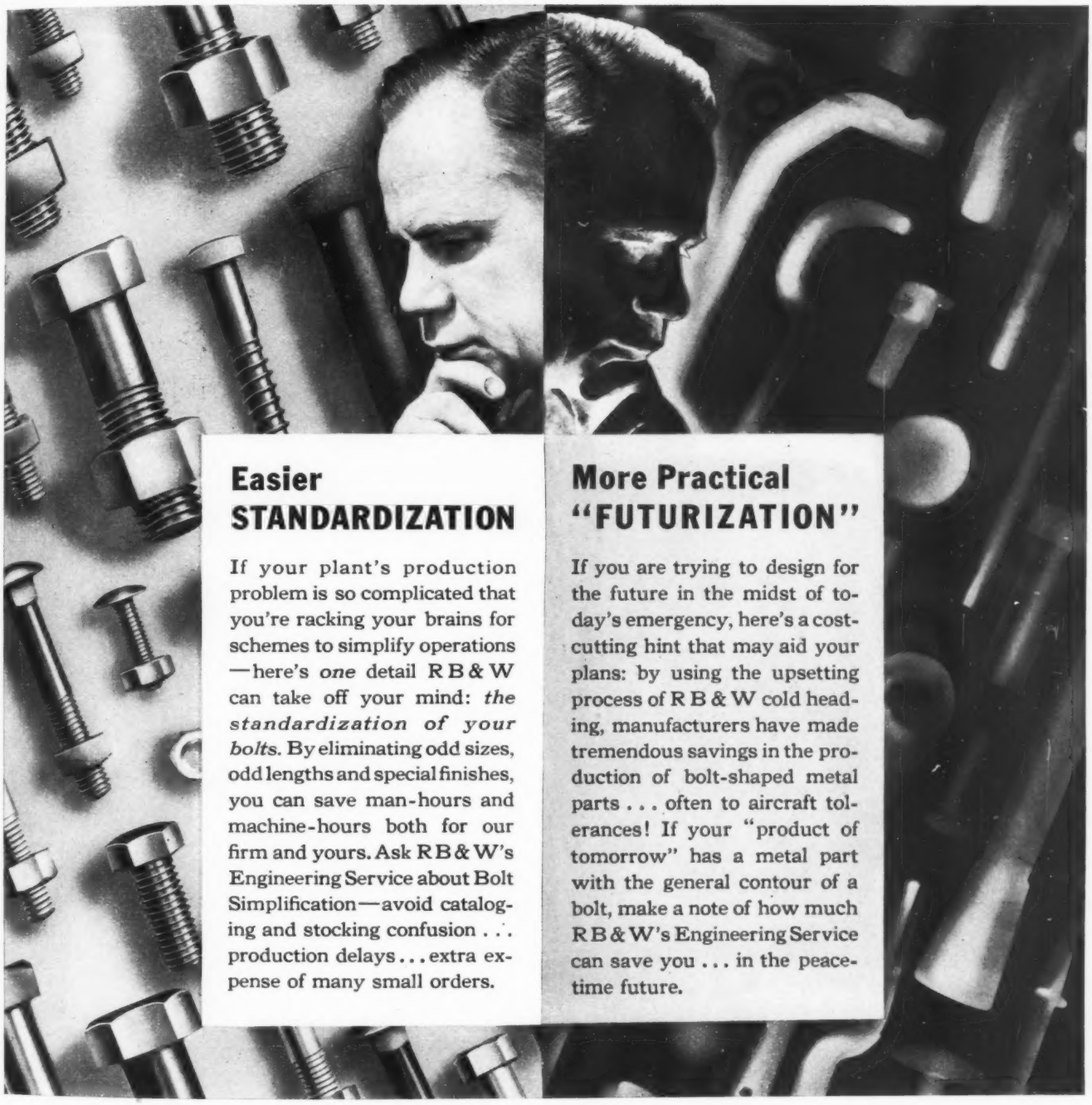


Time Delay Mercury Relay

SERIES BFV time relays offered by Durakool Inc., 1010 North Main street, Elkhart, Ind., can be used in modern communication systems, such as telephone and signal work, in machines, motors and electrical circuits where delayed action is required before a secondary or auxiliary circuit is called upon to operate. They can also be employed in recycling operations and flashing actions. This relay has delayed action upon closing of the control circuit, and after such delay, closes the main circuit. Upon

(*Continued on Page* 136)

Hints for schemers...AND DREAMERS



Easier STANDARDIZATION

If your plant's production problem is so complicated that you're racking your brains for schemes to simplify operations—here's *one* detail R B & W can take off your mind: *the standardization of your bolts.* By eliminating odd sizes, odd lengths and special finishes, you can save man-hours and machine-hours both for our firm and yours. Ask R B & W's Engineering Service about Bolt Simplification—avoid cataloging and stocking confusion . . . production delays . . . extra expense of many small orders.

More Practical "FUTURIZATION"

If you are trying to design for the future in the midst of today's emergency, here's a cost-cutting hint that may aid your plans: by using the upsetting process of R B & W cold heading, manufacturers have made tremendous savings in the production of bolt-shaped metal parts . . . often to aircraft tolerances! If your "product of tomorrow" has a metal part with the general contour of a bolt, make a note of how much R B & W's Engineering Service can save you . . . in the peacetime future.

RB&W **RUSSELL, BURDSALL & WARD** BOLT & NUT COMPANY

Factories at Port Chester, N. Y., Rock Falls, Ill., Coraopolis, Pa.
Sales offices at Philadelphia, Chicago, Detroit, Chattanooga, Los Angeles, Portland, Seattle

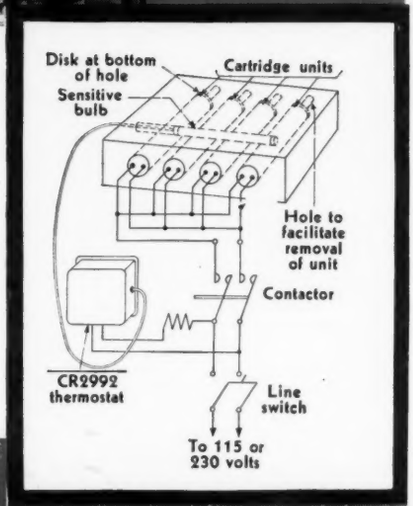
Making strong the things that make America strong

EMPIRE BOLTS NUTS RIVETS

AND ALLIED FASTENING PRODUCTS . . . SINCE 1845

Here's How to Spot Heat Exactly Where You Want It

The diagram shows how cartridge heaters are easily installed in drilled holes in platens such as the one on this wood-embossing press.



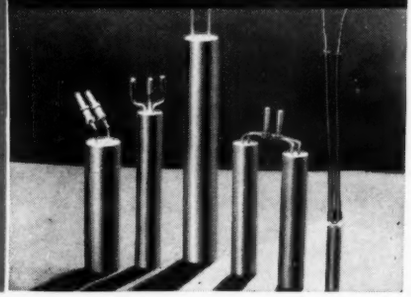
ELECTRIC HEAT

Built Right into the Machine

G-E Cartridge Heaters

From 1½ to 8½ inches long

Priced $2.20 to $6.60 each



FOR localized heat in your machines, these G-E cartridge heaters can't be beat. They are easily installed and controlled. Not affected by vibration, they are suitable for nearly all your machines that require spot heating. You can obtain temperatures up to 1200 F, and control the heat automatically with a thermostat.

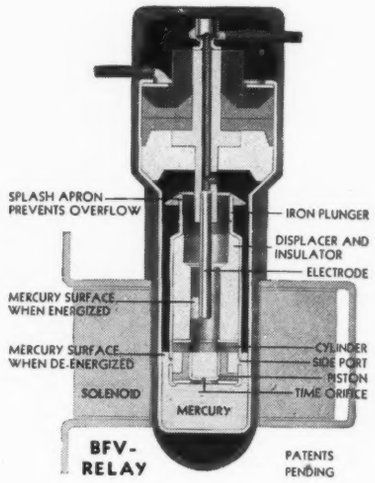
If you have a machine needing spots of heat here and there, submit details to our nearest office. Our engineers will figure out your specific requirements. For more information on G-E cartridge heaters or other Midget heaters and devices, get our catalog (No. GED-650B). *General Electric, Schenectady, N. Y.*

GENERAL ELECTRIC

676-52-8709

(*Continued from Page* 130)

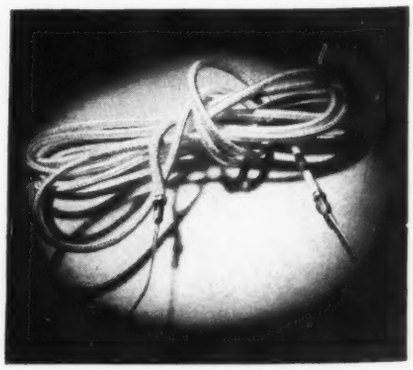
opening the control circuit, the main line opens instantly. The reverse of this action is also available, or "quick operate, slow release." Many other types of delays can be built readily upon the foundation of the BFV. Seventy-five amperes in the C model are available, while the B2 model (illustrated) has a maximum of 30 amperes. These explosionproof relays cool, quench and preserve their contacts as they operate. By paralleling the larger C relay, 140 amperes are obtainable, and by tripling, a



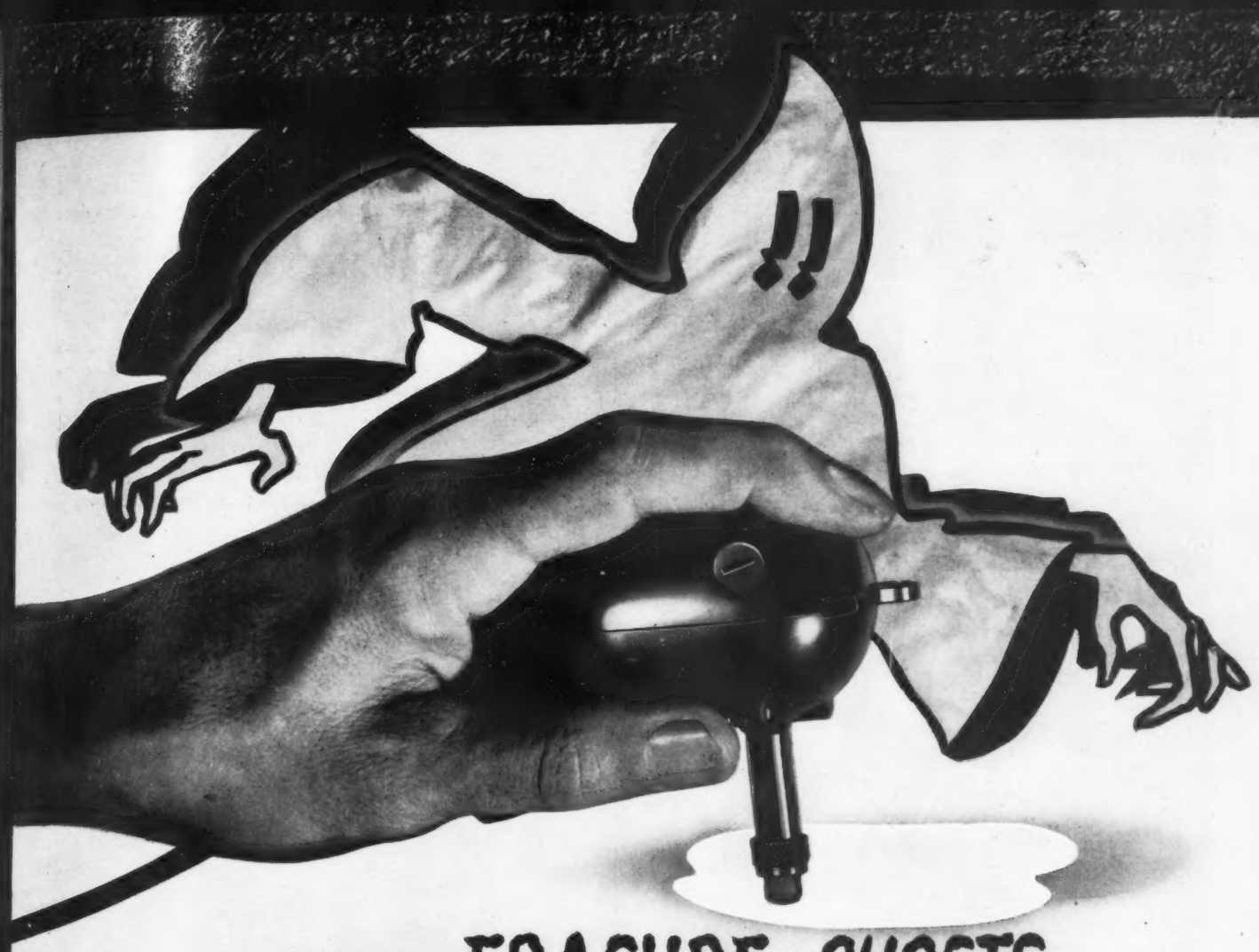
200-ampere capacity is available. With this relay it is possible to obtain slow closing and quick opening of the closing, slow opening contacts and quick closing, slow opening contacts. High pressure gas cools and quenches the arcing, and relays are recommended in applications where dust, dirt, moisture and explosive fumes are hazardous to electrical contacts. Capacitites up to 75 amperes, with solenoids wound for any voltage and frequency are available.

Heating Element Is Flexible

FOR limited space requirements a low-power, flexible heating element developed by Clarostat Mfg. Co. Inc., 285-7 North Sixth street, Brooklyn, N. Y., is finding many



uses. It is available in any length, by the inch, foot or yard, and is known as the Glasohm flexible power resistor.



DEFY ERASURE-GHOSTS
with this new tracing cloth

Here is a tracing cloth that holds erasure scars at a minimum—that won't show water marks or perspiration stains. Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. Its new white color and increased transparency give you excellent drawing contrast and produce strong blueprints.

Let PHOENIX prove its virtues on your own drawing board. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

EST. 1867
KEUFFEL & ESSER CO.
NEW YORK · HOBOKEN, N. J.
CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES · DETROIT · MONTREAL

PHOENIX DEFIES MOISTURE GHOSTS

Perspiration and water splashes on ordinary tracing cloth create "ghosts" which reproduce on blueprints. PHOENIX Tracing Cloth withstands actual immersion in water for fully 10 minutes at a time! *Perspiration and water marks will not stain it!*

PHOENIX LESSENS SMUDGE GHOSTS

The new improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

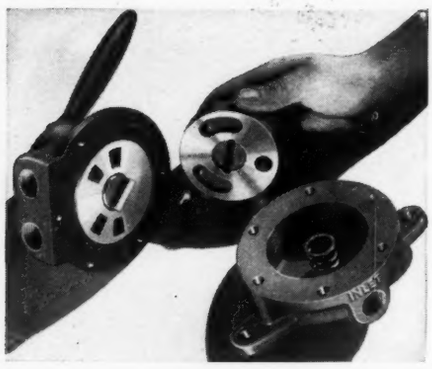
Result: Cleaner tracings and blueprints.

PHOENIX REDUCES ERASURE GHOSTS

Ordinary tracing cloths become scarred when erased... erased spots produce ghosts on blueprints.

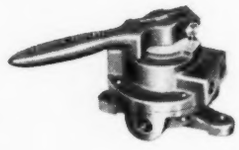
PHOENIX has a durable drawing surface that reduces working scars to a minimum.

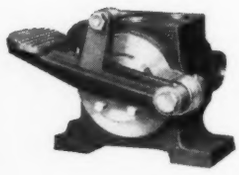
K&E
Phoenix
REG. U.S. PAT. OFF.
TRACING CLOTH
for pencil *and* ink



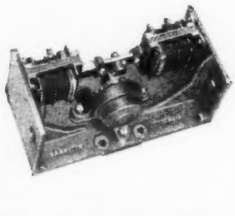
For *positive control* of air operated equipment

The simple and effective disc type design of Hannifin Air Control Valves provides positive, accurate control for any type of pneumatic equipment. Either throttling action or a quick, full opening may be obtained as desired, with smooth-acting, easily handled control.





This disc type design has no packing and no leakage or packing maintenance troubles. The bronze disc that controls air flow is ground and lapped to make a perfect seal with the seat which is similarly finished. Wear is negligible, yet if necessary after long service a simple relapping operation restores the original efficient seal.



Hannifin Valves give you a complete range of choice in hand and foot operated models, duplex valves, spring, return, manifold, and electric types. Write for Bulletin 57-MD with complete data on all types.

HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue • Chicago, Illinois

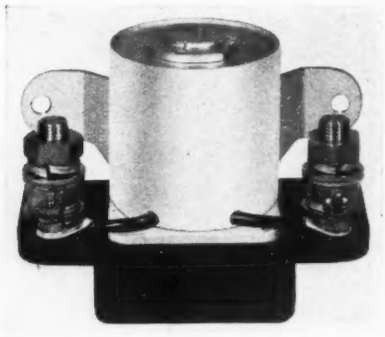
HANNIFIN

"PACKLESS" AIR CONTROL VALVES

In this construction the resistance wire is wound on a fiber-glass core and is protected by a fiber-glass braided covering. While providing unbreakability, the fiber-glass is almost as flexible as silk enabling the unit to be readily bent and compacted to fit snugly about parts to be heated or jammed into tight spots. Heating elements can be made in any required length, with any type of terminal. Wattage ratings are from 1 to 4 watts per body inch, depending upon application. Operating temperatures range up to 750 degrees Fahr. In addition to the use of the elements in low-power appliances, they can also be used in temperature-controlled ovens for oscillating radio crystals, the heating of aviation and marine instruments, localized heat for chemical apparatus and laboratory equipment, and similar applications.

Solenoid Contactor for Aircraft

AMONG the five new types of solenoid contactors announced by Guardian Electric Mfg. Co., 1601 West Walnut street, Chicago, for remote control of electrically actuated aircraft armaments, instruments and devices, is the B-4. Originally designed for airplane starting motors,



this contactor may be used for other applications of heavy-current control. It operates on 24 volts, producing a coil current of 300 milliamperes. Contacts are rated at 200 amperes at 24 volts direct current. The unit has double-pole, single-throw, normally open contacts, and can operate in any position. Weight of the control is 31 ounces.

V-Belt for Armored Vehicles

UTILIZING steel wires instead of conventional fabric or cord carcasses, new V-belts developed by Goodyear Tire & Rubber Co., Akron, O., are especially designed for motors of tanks and armored vehicles. Increased strength, higher resistance to heat and far less stretch is provided in the new belts. In armored vehicles these factors are deemed important because of the inaccessibility of fan belts and the tremendous amounts of heat developed by powerful motors which, due to the protective armor, have fewer facilities for removing this excess heat.

Phone-Switch for Communications

INTRODUCED by American Radio Hardware Co., 476 Broadway, New York, Type SW-141 phone switch is a vital connecting link between air and ground com-

Information supplied by "Machine Design"

"Overmotoring", the use of larger motors where smaller ones will do, wastes copper, other metal, labor, electricity and demands larger control and distribution accessories. "Overmotoring" is wasteful.

Users of electric motors can assist greatly in conserving critical materials and in helping spread available materials and manpower over a greater number of smaller motors, by selecting motors on the basis of actual expected duty without overstress on additional safety factors to care for unexpectedly heavy loads, or to lengthen motor life.

Motor builders today build sufficient safety factors into their motors to care for normal overloads, and the life span of standard motors is great enough to take care of all needs arising for many years.

Use of unnecessarily large motors also requires additional copper in distribution lines, larger switchgear and greater current demand.

A still further evil of "overmotoring" that cannot be overlooked or disregarded, is its effect on low power factor . . . another avoidable waste. Many well-designed plants are probably operating at 40 per cent power factor today, primarily because of "overmotoring".

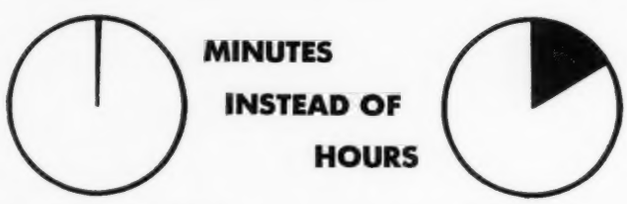
Specify and buy motors large enough to handle requirements, but never "overmotor".

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Mo-lyb-den-um Company
500 Fifth Avenue • New York City

MOLY

SAVE TIME
SAVE MAN POWER
with
QD SHEAVES



The patented QD Sheave design makes mounting or removing possible in sixty seconds—at the same time assures a positive press fit assembly to the shaft. This cuts hours off maintenance repair time, formerly required to remove the old type sheave—a factor that will yield maximum productive machine hours.

A MAN AND A WRENCH...NOT SEVERAL MEN AND MUCH MAINTENANCE EQUIPMENT.

No special tools are required to remove or install a QD Sheave, regardless of size—a tremendous advantage today when everyone's productive responsibilities are multiplied . . . and miscellaneous maintenance machinery is always in constant demand.

CONSERVE EQUIPMENT

Cracked sheaves, scored or bent shafts, burnt bearings, etc., resulting from removing the old type sheave with sledges, crow bars, wheel pullers, etc., have been definitely eliminated with the QD Sheave.

Call the Worthington District Office near you for a demonstration. Offices in all principal cities.

MEMBER MULTIPLE V-BELT DRIVE ASS'N

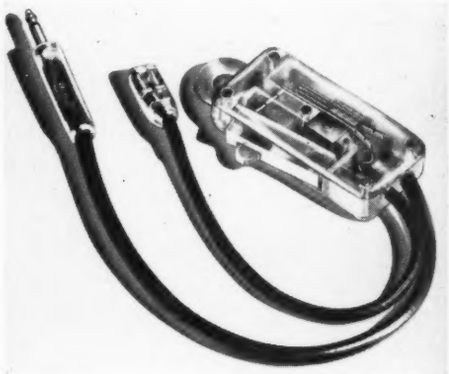
For complete details on the QD Sheave write Worthington for a copy of the new bulletin V-1400-B7.

WORTHINGTON

MV2-6

WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY • Offices and Representatives in Principal Cities

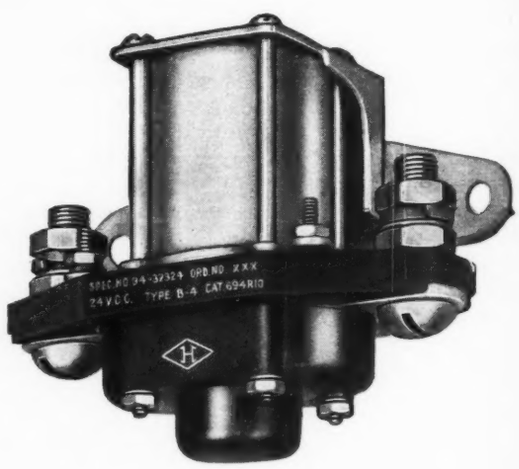
munications. This double circuit microphone switch remains in open position normally and can be locked into closed position. Dimensions are 4-15/32 inches in length, ¾-inch thick and 1¾-inch wide. Plastics are used in the construction of the switch which is mounted on



sturdy brass brackets, with blades made of phosphor bronze. It is heavily nickel-plated, with bakelite insulation. As an integral part of the housing, cordage clamps for taking up cable strain are provided. The switch is primarily used by aircraft radio operators because of its precision qualities.

Aircraft Continuous Duty Relay

WHILE the new single-pole, double-break relays introduced by The Hart Mfg. Co., Hartford, Conn., are designed specifically for aircraft use, they are finding many other applications. Without sacrificing either mechanical structure or electrical operation, weight of the relays has been held below 1¾ pounds. The relays will operate in any position under accelerations up to 15g. Mechanical vibrations of 5 to 55 cycles per second at a

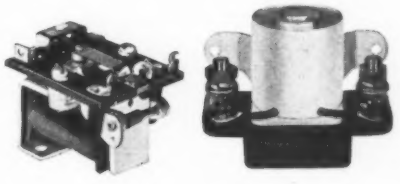


maximum of 1/32-inch amplitude (1/16-inch total excursion) applied in any direction will not cause failure. Without injury to the contacts, momentary overloads of 1500 amperes can be safely broken. Coils are of continuous duty type and operate on low current. Double-break contacts are a special silver alloy. Load terminals are silver-plated copper. This relay, with its construction

Relays BY GUARDIAN · · · SERVE ALL FRONTS!

★ **Yuletide joys of '42 will not include the many electrical gifts which brought us cheer, and ease, and comfort in other years. Relays by Guardian have marched on from peacetime industry to the firing lines of war. Doing war jobs in many ways . . . in planes . . . in tanks . . . in communications . . . in bomb releases and gun controls. Wartime jobs which Guardian anticipated and planned long before "Pearl Harbor".**

But, while thinking, building, and engineering the tools of war today, Guardian again is looking *ahead* to peacetime applications of Relays, Solenoids, Electrical Controls of all kinds. If you are making plans for "after-it's-over", ask our engineers to plan with you. Write to Guardian. Our wartime experience can help you build better products for the future.

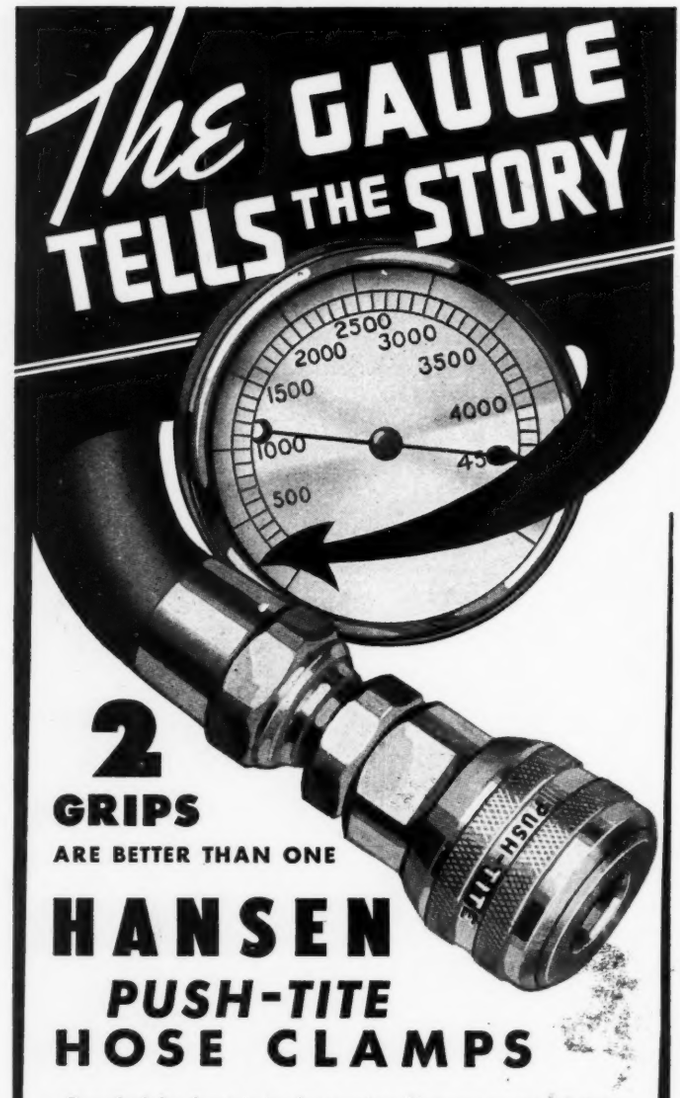


CONTROLS FOR ANY PURPOSE... *ranging from 150 watts to 1000 amps . . . from tiny relays weighing less than an ounce . . . to big, rugged two-pound contactors.*

GUARDIAN ELECTRIC

1601 WEST WALNUT STREET — CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY



2 GRIPS ARE BETTER THAN ONE

HANSEN
PUSH-TITE
HOSE CLAMPS

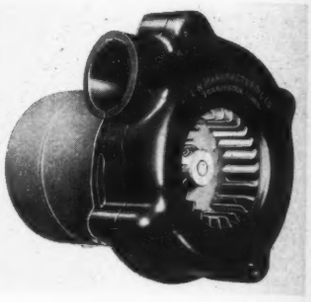
Proof of the facts is in the testing. Hansen compression type hose clamps have proven in actual laboratory tests that they will take over 5000 pounds pressure and we recommend a safe working pressure from 800 to 1000 pounds. With Hansen hose clamps it's two grips, one on inside of hose, one on outside, as compared with only one grip found in ordinary hose clamps. Extremely easy to install it's merely a matter of screwing stem into hose, takes but a few seconds. No extra parts or replacements and remember they're very economical—can be used many times over. With Hansen hose clamps it's a two to one advantage. Send for free catalog.

Hansen MFG. CO.
INDUSTRIAL AIR LINE EQUIPMENT
1786 E. 27TH STREET • CLEVELAND, OHIO

and operation well within the limits of the U. S. Army Air Corps specifications, is available for continuous duty service on either 12 or 24-volt, direct-current circuits, and can be supplied with certain variations such as other coil characteristics and mounting brackets.

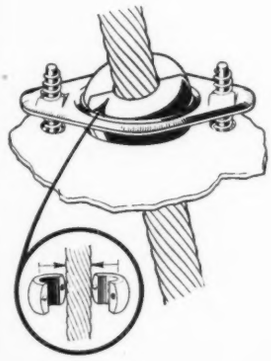
Blower Has Universal Mounting

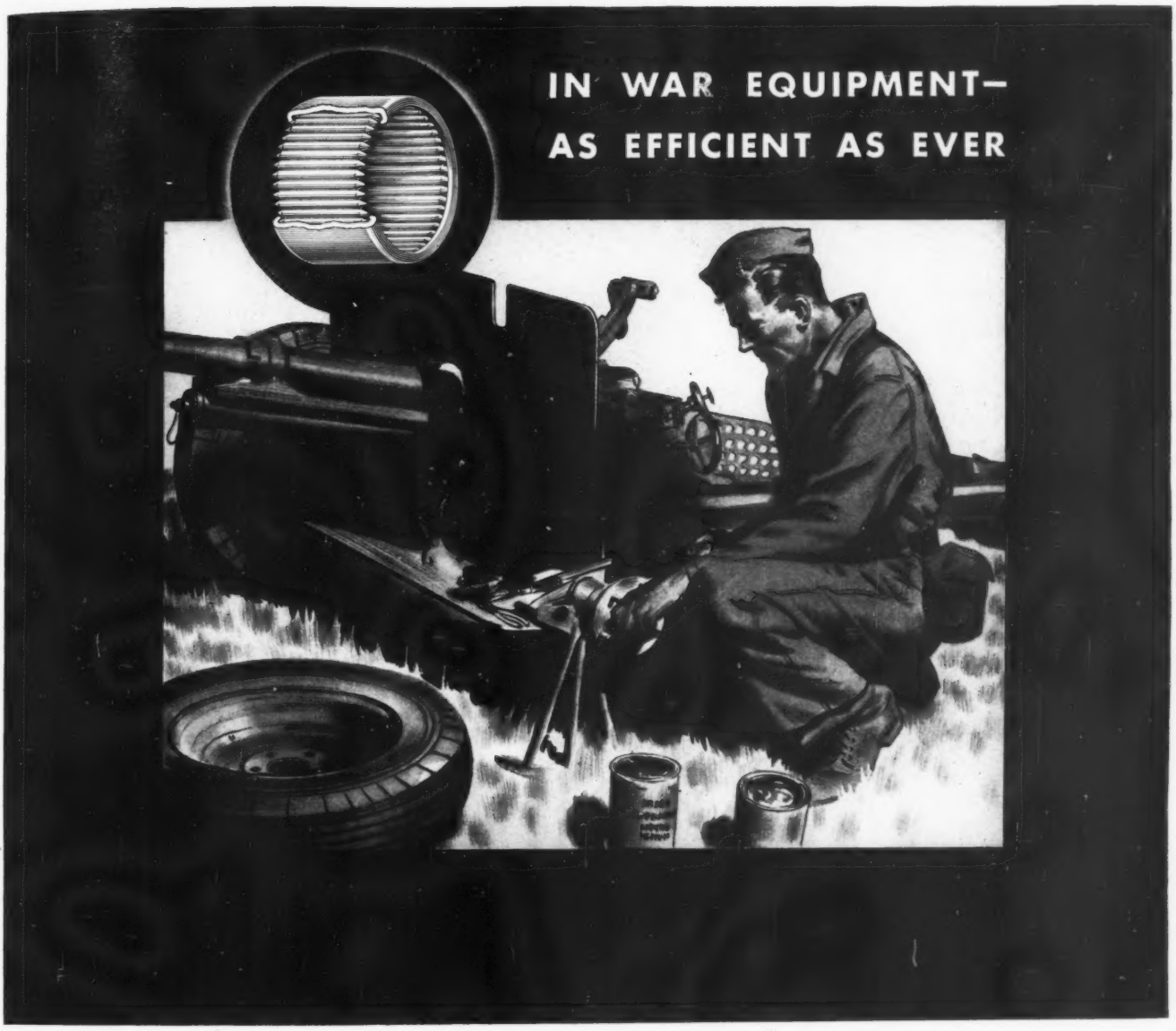
COMPACT in size and flexible in mounting requirements, a new blower unit of L-R Mfg. Co., Torrington, Conn., is constructed of noncritical materials. Built to function under difficult conditions imposed by electronic equipment, the blower can be adapted to many uses. Having a housing of high-impact plastic capable of withstanding temperatures to 375 degrees Fahr., the unit wheel and housing weigh 4½ ounces. The wheel is turbo type, ¼-inch shaft, tin plated, and is 2 inches in diameter. Two set screws are located in the hub at an angle of 90 degrees. Output is 39 cubic feet per minute at 8400 revolutions per minute. Mounting is universal with motor plate for any small motor. It is assembled with bracket supports for various methods of mounting. Any small motor can be used such as 1/100-horsepower operating on voltage supplies of 6, 12, 24 and 28 volts direct current, and 110 volts at 60 cycles alternating current and 115 volts at 400 cycles alternating current.



Adjustable Fairlead Guide Block

MANUFACTURED by Tinnerman Products Inc., 2085 Fulton road, Cleveland, a new adjustable guide block that is universal for any angle of cable is comprised of a three-piece macerated fabric-filled phenolic plastic guide which is housed between an aluminum base and a special spring steel speed nut. The guide is universal for any angle of cable, and may be replaced easily without unthreading the cable. Eccentric center plug is rotatable for centering cable. The fairleads accommodate cables up to 3/16-inch in diameter and are boxed in single sets including Air Corps 530-8 screws and instructions for assembly. Where a 29/32-inch diameter hole is practical in structure, a different fairlead is used, which has no aluminum base. The plastic guide is housed in a 29/32-inch diameter hole in the structure and is held firmly in place with the top speed nut. Still another





TODAY it may be an anti-tank gun, stripped for check-up... tomorrow, the still-warm "heart" of a fighter plane. So it goes. Fighting equipment gets tough treatment in modern warfare. So the need for frequent servicing and constant parts replacement is understandable.

But there is one vital part which maintenance men seldom have to touch, although they notice it often enough. The Torrington Needle Bearing, "changed over" to production-for-war, is again demonstrating its efficiency—and adaptability—in applications where its unique advantages mean more today than ever.

Its efficient system of lubrication, for example, which requires only occasional oiling, is reducing the need for maintenance attention or replacement. Its high capacity assures long bearing life, even in continuous operation under heavy loads.

Every feature of the Needle Bearing, significantly, is filling some important wartime need. Its small size is saving weight and critical materials; its remarkable ease of installation is cutting assembly time; its simplified design is eliminating extra parts and assembly steps, with low coefficient of friction assuring smooth performance.

When Victory may hang on the amount of time it takes to service fighting equipment, it is not surprising that maintenance men these days are finding Torrington Needle Bearings in more and more of America's war materiel.

***IF YOU HAVE A PROBLEM** which the Needle Bearing might solve, Torrington engineers can be of valuable assistance in adapting its advantages to your needs. You are welcome to their experience, as well as the information on Needle Bearing capacities and sizes in Catalog No. 110.*

THE TORRINGTON COMPANY
TORRINGTON, CONN., U. S. A. • *Established 1866*
Makers of Needle and Ball Bearings

New York · Boston · Philadelphia · Detroit
Cleveland · Seattle · Chicago · Los Angeles
San Francisco · Toronto · London, England

TORRINGTON NEEDLE BEARING

Every feature fills a wartime need

MAY BE THE ANSWER

TO YOUR CRITICAL MATERIAL PROBLEM!

Prior to our entrance into the War, practically *every* industry in America was using FELT for one purpose or another. Only in a few instances, however, was FELT used in *all* the applications for which this most versatile material is suitable.

As shortages of rubber, cork, leather, etc., developed, engineers and production men were obliged to seek less critical materials. Learning the technological advances that have been made in FELT, and studying its properties, many firms have found that not only is FELT a good alternate for other, more critical, materials but that in most instances the *inherent* properties of FELT entitle it to primary consideration.

Reasonably prompt shipments of FELTS which meet all Government specifications can be made. If FELT can help you to produce for Victory *you* want to know about it. *We* can tell you.

THESE FACTUAL DATA SHEETS ARE AVAILABLE

No. 1, Felt Density; No. 2, Adhesives for Felt Application; No. 3, "K" Felt for Acoustics; No. 4, Special Felt Treatments and Prices; No. 5, S.A.E. Felts—American Felt Co. Standards; No. 6, Felt and Lubrication; No. 7, A.S.T.M. Tentative Test Methods for Wool Felt; No. 8, U. S. Army Spec. 8-15 E; No. 10, Vibration Isolation; No. 11, Annular Designing and Dimensioning.

American Felt Company

TRADE MARK

General Offices: GLENVILLE, CONN.

New York; Boston; Chicago; Philadelphia; Cleveland; Detroit; St. Louis; San Francisco

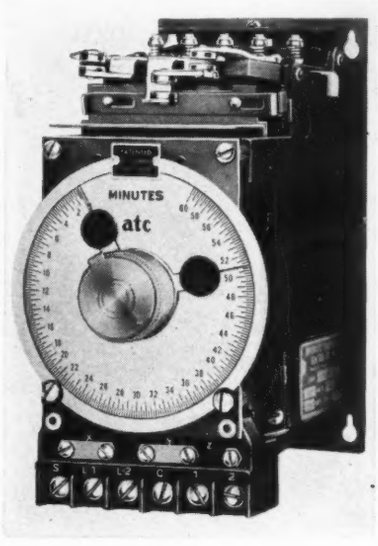
Producers of finest quality FELT

We recommend that you buy to Army, Navy, S. A. E. or Felt Association Standards

type of fairlead is available, using a two-piece graphitized phenolic plastic guide, which not only is used as a fairlead for cables, but is employed as a control rod bearing. Natural graphite is impregnated into the plastic, making the guide self-lubricating. This type is available in fifteen different hole sizes to accommodate cables or control rods from 1/16 to ½-inch in diameter. Permitting prepunching or drilling of fairlead holes and making unnecessary drilling of angular holes in fairleads, the new fairleads greatly increase speed of assembly.

Cycle Timer Improved

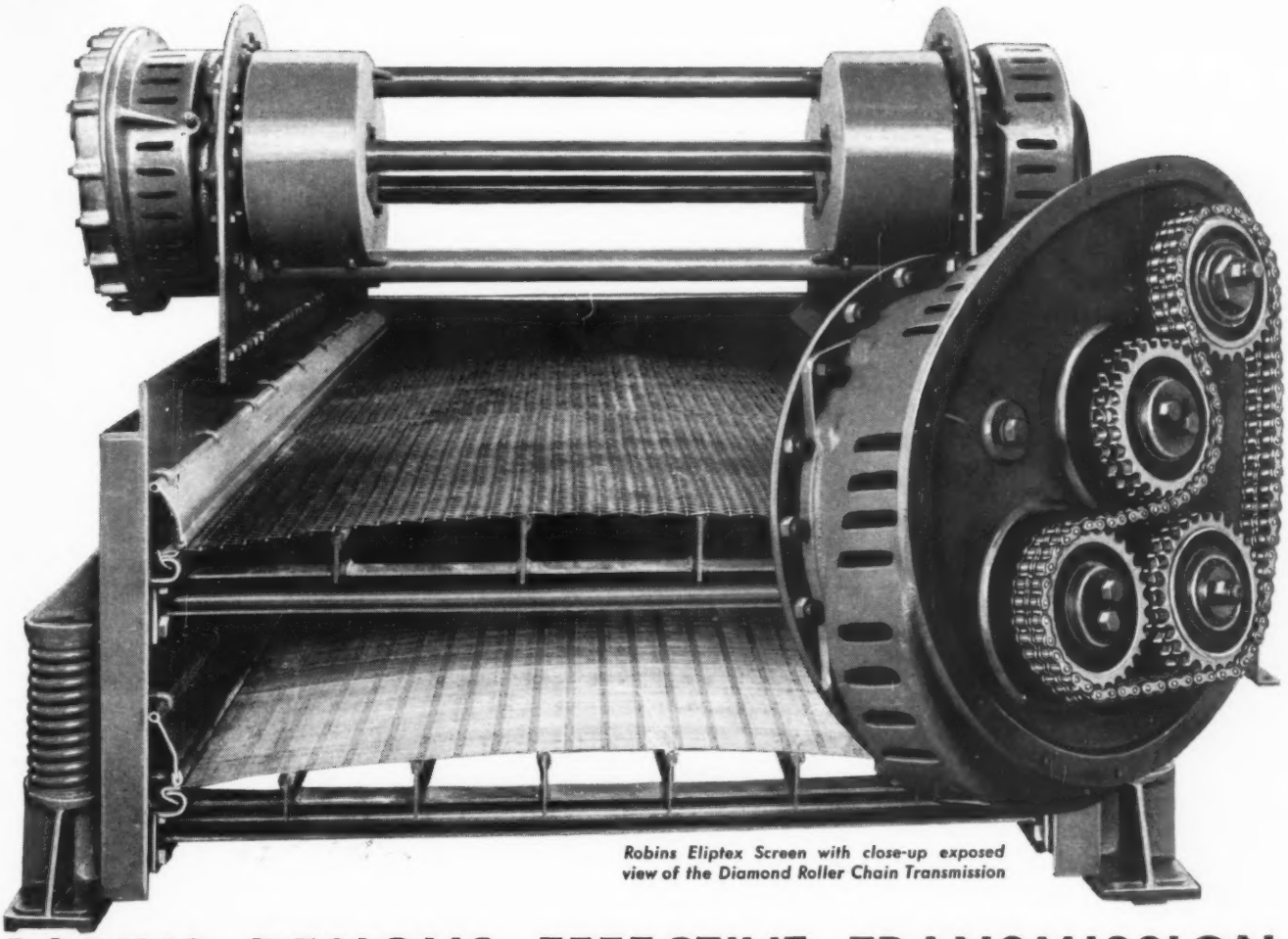
DESIGN improvements have been made by Automatic Temperature Control Co. Inc., 34 East Logan street, Philadelphia, in its series 2800 cycle-progress timer. Improvements are: Contact rating has been changed, new terminal block has been supplied, new wiring is in effect, a leaf-spring contact has been added, and several new dial ranges are now available. The



timer is used where timed operation on a stop-cycle basis is required for machines or processes, and where it is desired to have an indication of the "time elapsed" or "time to end of cycle", in diecasting machines, molding presses, automatic quenching machines, soaking period control, automatic mixing, etc. Telechron motor-driven and equipped with a "no-locking" knob, the timers are available for operation from 110 or 220 volts, 25, 50 or 60 cycles. Contacts of 3/8-inch fine silver will carry loads to 25 amperes at 110 volts alternating current, non-inductive. The units may be supplied for resetting or nonresetting action upon power failure. Dials may be selected from any of the following: 1/4, 1, 2, 10, 20, 40 or 60 hours.

Coolant Pump Is Portable

KNOWN as Spiegel-Spray pumps, a new line is being manufactured by G. B. Spiegel Corp., 3958 South Calumet avenue, Chicago. These pumps are suitable for 24-hour production use on lathes, screw machines, drill presses, grinders, milling machines, etc., and range in capacities from 150 to 1500 gallons per



Robins Eliptex Screen with close-up exposed view of the Diamond Roller Chain Transmission

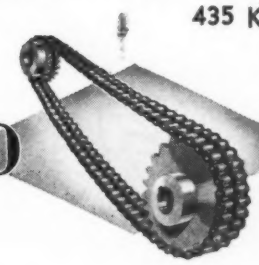
ROBINS DESIGNS EFFECTIVE TRANSMISSION

Diamond Roller Chains Meet Stiff Requirements

• In the development of the large Robins Eliptex Screens, the designing engineer believed a roller chain transmission could be designed to accomplish the required results. Although several chain makers considered the job "too tough,"—a DIAMOND Roller Chain system was devised which completely solved the problem. This transmission consists of two driver sprockets, an adjustable idler sprocket mounted on an eccentric and another idler to maintain satisfactory wrap of the Diamond double-strand Roller Chain employed. Two shafts are driven in opposite directions at high speed, each shaft carrying unbalanced weights, the compound centrifugal force giving the screen its elliptical motion.

The fact that the transmissions now used on the many Eliptex Screens in service have required no replacements proves the soundness of the design and of the selection of Diamond Roller Chains for the job.

Whether for driving production machinery, or as built-in drives on machines themselves, DIAMOND Roller Chains insure maximum efficiency, dependable long-life performance, top production output. With 52 years of experience in roller chain applications, our engineers can help you to arrive at a satisfactory drive,—even where it may look as if "It Can't Be Done." DIAMOND CHAIN & MFG. CO., 435 Kentucky Ave., Indianapolis, Ind. Offices and Distributors in All Principal Cities.



DIAMOND ROLLER CHAINS

"No Visible Signs of Wear"
CASE D2142
Large worm gears of Ampco Metal, grade 18-23,
Operating conditions: Marine Service
Unit stress on teeth: 6000 lbs. per sq. inch
Rubbing speed: 200 ft. per min.
RESULTS:
12 months without visible signs of wear.

AMPCO Bronze

Worm Gears Stand Up Under Heavy Loads

Microstructure of Ampco Metal, Grade 18-23

In Marine service—often miles at sea where breakdown cannot be tolerated—Ampco gears stood up month after month and showed no signs of wear. Here again the bronze proved its merit under tough service conditions.

Ampco Metal grade 18-23, has all that is needed in a gear bronze-bearing properties; correct microstructure; shock resistance; strength under dynamic loading; and hardness to resist brinnelling and deformation under extreme load conditions. It has proved itself under varying applications to be an outstanding bronze for gear service, and is backed up by 28 years experience in alloying bronze.

Thoughtful plant executives will investigate Ampco Metal. Ask for free bulletin "Ampco Metal in Gears."

AMPCO METAL, INC.
Department MD-12 **Milwaukee, Wis.**

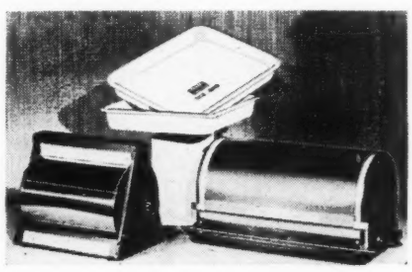
AMPCO METAL
THE METAL WITHOUT AN EQUAL

hour, with tanks from 3½ to 15 gallons. Special features of the pump are: Nonclogging centrifugal pump with no gears or close-fitted parts to wear or jam; no metal to metal contact; removable strainer; completely portable, self-contained unit; accurate flow control valve delivering the proper amount of coolant with a spray nozzle to deliver coolant where it is needed. Special units having special sizes or shapes of tanks with larger or smaller pumps can be furnished.

Engineering Dept. Equipment

Machine Copies Blueprints

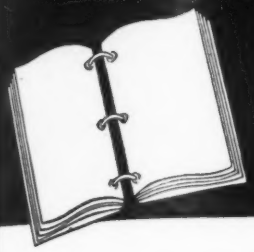
COPIES can be made from blueprints, drawings or tracings, special wiring or mechanical diagrams, specifications, usable new copies of old tracings, departmental orders, etc., with the new photocopy machine brought out by American Photocopy Equipment Co., 2849 North Clark street, Chicago. The machine produces copies similar to photostats, the actual size of the original, of anything written, typed, printed, drawn or photographed. No dark room is necessary and no particular skill or technical knowledge, to operate the machine. The article to be copied together with a piece of paper is simply placed on the operating surface. The contact cover is then closed and the switch pressed, exposing the paper for a few seconds. The exposed paper is placed in the developer for a half minute and allowed to stand in tray of fixer for several minutes. It is then briefly washed and dried. The materials used are harmless and odorless. The company furnishes the photocopy paper, developer and fixer, trays and dryers or blotter books.



Blueprint Developer

NONCORROSIVE, nonpoisonous blueprint developer is being offered in place of the customary potash solution by Wisconsin Pharmacal Co., Milwaukee. Known as Hi-Tense, it is noncorrosive to equipment, will not spot workers' clothing or injure fabric, produces clear, bright blueprints and does not leave brown spots. This developing solution is made up on a 1-40 ratio (Hi-Tense and water), and hands may be immersed without danger of dermatitis or skin irritation. While the solution is not recommended for machine developing, it is said to be unexcelled for all hand and tank work.

Designing Molded Plastics Parts: ELECTRICAL PROPERTIES



From the engineering files of One Plastics Avenue

DIELECTRIC STRENGTH is the resistance which an insulator offers to breakdown by an electric potential. Test procedure represents different types of service and gives widely different results:

1. Short time test: Voltage is applied at a steady rate, usually 1000 Volts per second.
2. Step by step test: Stepped voltages are applied for one-minute intervals until failure. The steps are portioned so that failure occurs in about ten steps.
3. Endurance test: A step by step test with thirty-minute or hour intervals.

Dielectric strength will be lowered by sharp electrodes, long application of voltage, high moisture content, high temperature, and high frequency voltage. In thick pieces, the strength per mil is lower. At radio frequencies, dielectric strength may be only 10% of room temperature, 60-cycle, short time value.

THE POWER FACTOR is the direct percentage of power lost due to the phase difference between the voltage and the current. In a perfect insulator, the current is 90° out of phase, and the power factor is zero per cent.

THE DIELECTRIC CONSTANT of a material is the ratio of the capacitance of a condenser employing that material to the capacitance of a condenser with an air dielectric. This ratio is generally greater than one.

THE LOSS FACTOR of a given insulator is the product of the power factor times the dielectric constant.

ARC RESISTANCE is measured by the number of seconds which are necessary to cause failure on the surface of a plastic when subjected to a given electric current arc. Failure is due to carbonization of phenolic materials and to fusing or melting of thermoplastics material. Best arc resisting compounds are fiber, natural resins, thermoplastics, cold molded and urea.

TYPICAL APPLICATION—Molded tap changer for a transformer having good dielectric strength and power factor.

FACTORS AFFECTING ELECTRICAL PROPERTIES. Values for electrical properties are greatly affected by the method of making the test, by the operating and service conditions, and by other external factors. Translation of test results to service conditions must be carefully made, and suitable safety factor allowed.

1. High operating temperature lowers dielectric strength, arc resistance and raises power factor. For highest operating temperatures, cold molded refractory, mycalex, and asbestos filled phenolic are best.
2. High moisture absorption lowers dielectric strength and arc resistance and increases power factor and dielectric constant. Parts operating in highly humid atmospheres will be greatly affected. Plastic surfaces which have been machined or scratched will be especially susceptible to moisture absorption and will have poor arc resistance.
3. Parts subjected to radio frequencies have much lower values of dielectric strength. Results reported at low frequencies cannot be translated for work at high frequencies.
4. Where electric arcs are possible, design the part with air gaps and metal inserts to prevent the arc from traveling on the plastic surface and carbonizing or melting the compound.
5. Inserts or metal assemblies with sharp corners or points raise the voltage gradient and lower dielectric strength.
6. Apparatus requiring electrical shielding may be housed in a plastics case whose surface has been metallized.

TABLE OF VALUES (1/8" Thickness)

	DIEL. STRENGTH				POWER FACTOR (25° C.)			Diel. Constant Values approx. same for 60 to 10^6 cycles	Arc Res.
	Short Time		Step by Step						
	25° C.	100° C.	25° C.	100° C.	60c	1 kc	1 mc		
Phenolics:									
Wood Flour Filled	400–450	80–120	200–350	60–100	.04–.1	.04–.10	.03–.10	4–8	Poor
Mica	400–600	400–600	350–500	350–500	.01–.02	.01–.02	.007–.010	4–8	Fair
Fabric	200–600	250	200–400	40	.08–.3	.08–.10	.08–.1	4–8	Poor
Phenolic Laminated:									
Paper (X)	500	.....	360	.....	.....	.....	.....	.....	Poor
Paper (XX)	500	.....	360	.....	.....	.....	.040	5.0	Poor
Asbestos	50	.....	30	.....	.....	.....	.....	.....	Poor
LE	360	.....	220	.....	.....	.....	.045	5.0	Poor
CE	360	.....	220	.....	.....	.....	.055	5.5	Poor
Urea	400	300	350	100	.04–.05	.03–.04	.03–.04	6–8	Good
Styrene	500–700	.....	500–525	.....	.0002	.0002	.0002	2.6	Good
Mycalex	350–380	.....	.....	.....	.....	.006	.002	7.5	Very good
Cellulose Acetate	350–900	.....	.....	.....	.01–.06	.01–.06	.01–.05	3.5–6.5	Good
Methacrylate	500	.....	400	.....	.05–.07	.06–.07	.015–.03	3–4	Good
Cold-molded, non ref.	85	60	50–85	.....	.2	.....	.07	15	Moderate
Cold-molded, ref.	60	60	25–50	.....	.....	.....	.....	.....	Good
Hard Rubber	400–500	400–500	370	370	.03	.03	.003–.008	3	Very good
Mica	.....	.....	.....	.....	.00 3	.0002	.0002	7–7.3	Very good
Porcelain	.....	.....	.....	.....	.....	.....	.003	6.5	Very good
Glass	.....	.....	.....	.....		.006	.002	4.5	Very good
Quartz	.....	.....	.....	.....	.0002	.0002	.0002	4	Very good

ADDITIONAL FACTS. Plastics are natural insulators and are employed in electrical uses in the form of molded parts, sheets, rods, tubes, coatings and varnishes. G.E.'s consulting engineering service will advise you on best methods of design.

REPRINTS of this advertisement may be obtained by writing Section D-12, General Electric Plastics Department, Pittsfield, Mass.

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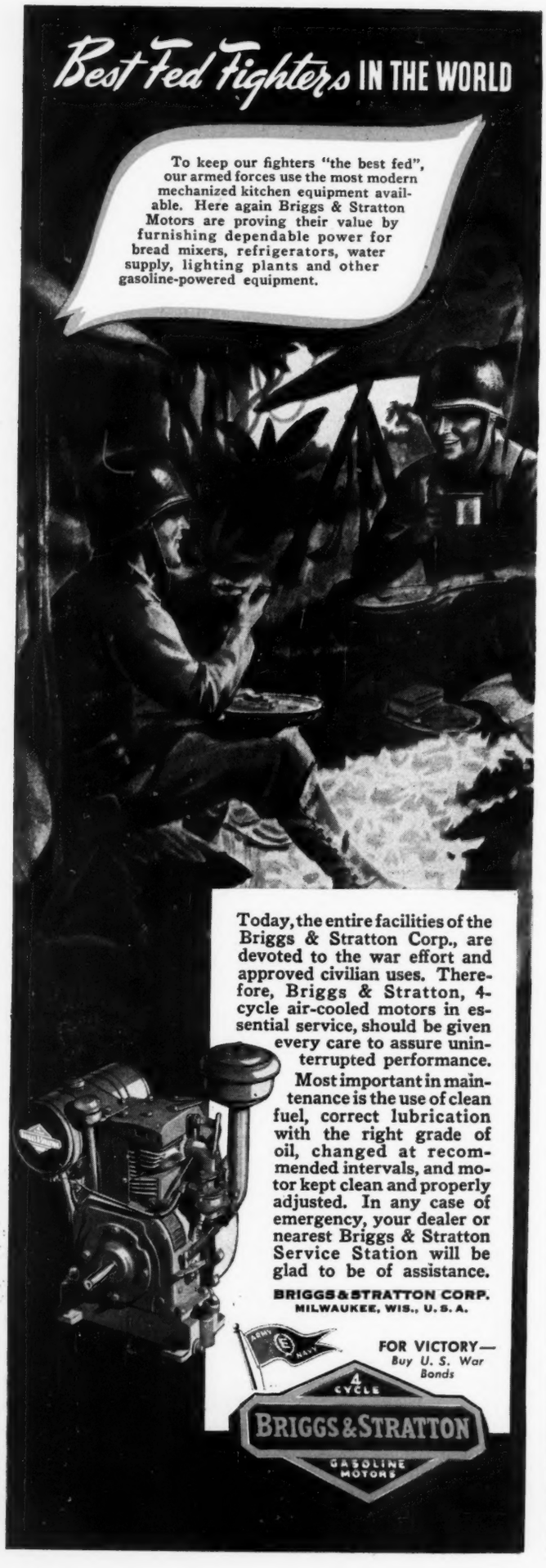
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PROFESSIONAL VIEWPOINTS

" . . . silver bearings are not troubleproof"

To the Editor:

I am glad to see the straightforward articles on "Practical Aspects of Bearing Design" by Etchells and Underwood in your September and October issues. They make clear the possibilities of scientific calculation of bearings for specific conditions and indicate some of the many factors that affect the attainment of these conditions.

I was fortunate in hearing the authors present the original paper before the S.P.E.E. in which they were critical of the empirical treatment of bearing design in text books. I should like to draw attention to the treatment of bearing design in *Fundamentals of Machine Design,* by Norman, Ault, and Zarobsky (Macmillan) which follows the methods of Needs as does the article by the authors in MACHINE DESIGN. This text was first printed in 1938.

Mention is made of the desirability of the circumferential groove for lubricating a bearing although it results in two bearings each with an L/D ratio less than half the ungrooved bearing. It is true, as mentioned, that the capacity is thereby diminished but only on the assumption that the viscosity remains the same in the two instances. Is it not true that the circumferential grooves results in a greatly increased oil flow with consequent reduced temperature rise in the oil? Is not this smaller temperature rise in the oil passing through the bearing, with the corresponding decreased change in viscosity of the oil, sufficient to offset this loss in bearing capacity due to decreased L/D?

The authors state that the idea of "hard particles in a soft matrix" as a necessary characteristic of a bearing material "has been repeatedly disproved". Silver bearings have been mentioned in this respect but I understand that, under conditions of boundary lubrication, they are not troubleproof.

—E. S. AULT
Purdue University

" . . . use determines bearing metal"

To the Editor:

Professor Ault's statement that the load capacity of a bearing is increased by the addition of an oil groove is unquestionably true, if there is a sufficient increase in oil flow. In this change, we have two factors which are opposed to each other. The groove reduces the capacity while the increased oil flow increases the capacity. There is no assurance that a sufficiently increased oil flow will be attained in all cases. The net result in any particular bearing depends on the relative importance of the two effects, and therefore no universal answer is possible.

Very little data have been published on the friction of metals, although industry has investigated the subject

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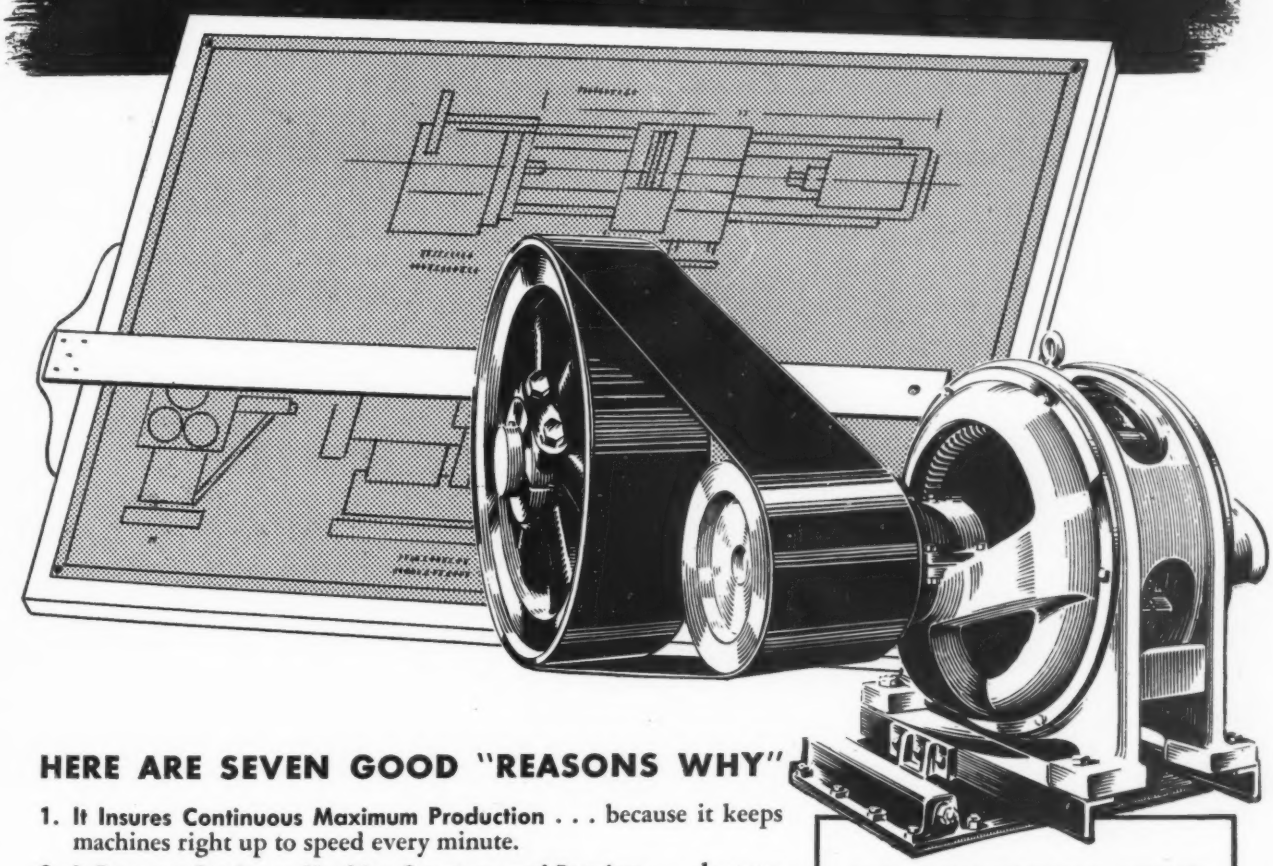

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extensively. John Goodman ("White Metals for Antifriction Purposes," *Engineering,* London, March 21, 1930, Page 378) reports that pure lead is an excellent bearing material until its compressive strength is exceeded. Boegehold (Discussion of paper by Upthegrove, "Automotive Bearing Metals," Symposium on Developments in Automotive Materials, A.S.T.M., 1930) stated that pure tin gave the best results of all the various types of bronzes and babbitts from the standpoint of wear and bearing temperatures.

In the paper "Some General Aspects of Rubbing Surfaces", presented before the Conferences on Friction and Surface Finish at M.I.T., June, 1940, I developed the principle that the effectiveness of a bearing material was shown by its location on the periodic table. Metals in the odd-numbered series are used as bearing materials. Those in the higher series give increasingly better antifriction properties. As an example, aluminum and magnesium, located in Series 3, are poor bearing materials. By comparison gold, thallium and lead, in Series 11, are excellent materials.

The softer metals in the higher series are too weak so that crystals must be added to increase their rigidity. If the soft metal is used in thin layers so that its effective rigidity is greatly increased, then no additional crystals are necessary. Tin, copper, cadmium, lead and indium are extensively used as thin-plated layers. If it is necessary to utilize a higher strength bearing material such as copper or silver, another element having better antifriction properties must be used in conjunction with it when the best antifriction characteristics are required. Copper-lead and silver-lead bearings belong to this class.

As mentioned by Professor Ault, pure silver which is located in Series 7 is not troublefree and therefore the bearing industry is using lead to further improve the antifriction properties of silver for boundary lubrication conditions. It is interesting to note that tin (which has as excellent antifriction properties as lead) cannot be used with silver as it forms an unsuitable alloy.

In our investigations, we have been unable to find any evidence that hard crystals to support the load and a soft matrix to allow adjustment are required although they can be seen through a microscope.

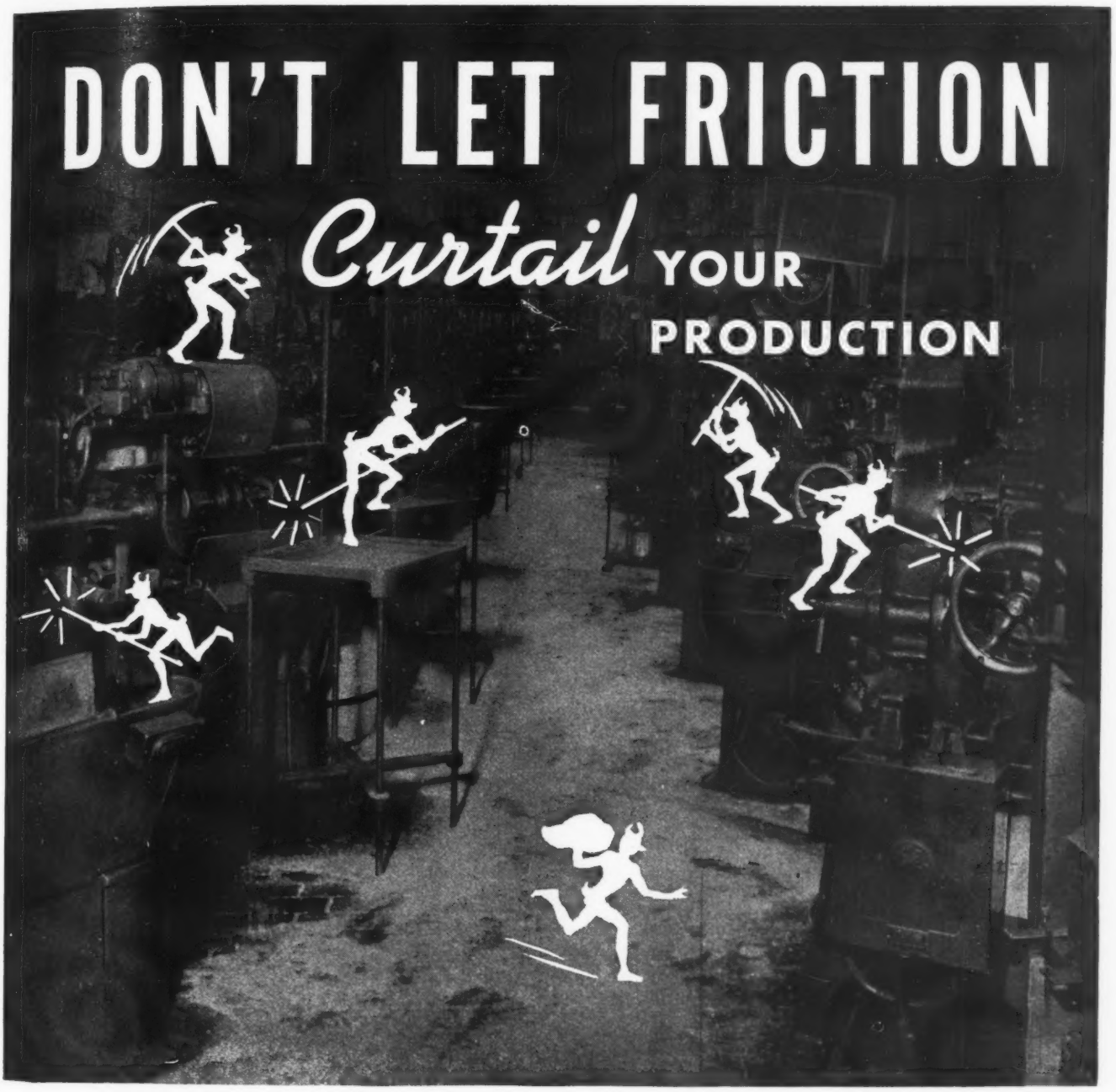
There are so many different requirements for a bearing material that it is often said that the proper one is the one that works. In a given engine, babbitt may be used for the journal bearings, copper-lead for the connecting rod bearings, lead-bronze for the wristpin bushings and pure tin plated over aluminum for the pistons.

—Arthur F. Underwood,
General Motors Corp.

" . . . determining linkage acceleration"

To the Editor:

In the interesting article by H. A. Bolz, "Simplifying Graphical Solution of Linkages", in the May issue of Machine Design, the velocities of the four-bar linkage have been determined by graphical means directly from the mechanism, whereas the acceleration was found by algebraic methods. There exist numerous geometrical solutions for the accelerations of Joint 3 of the four-bar linkage (see *Fig.* 1). A very simple solution is that of Gruebler which is based on the diagram of the velocities



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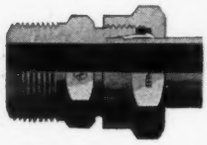

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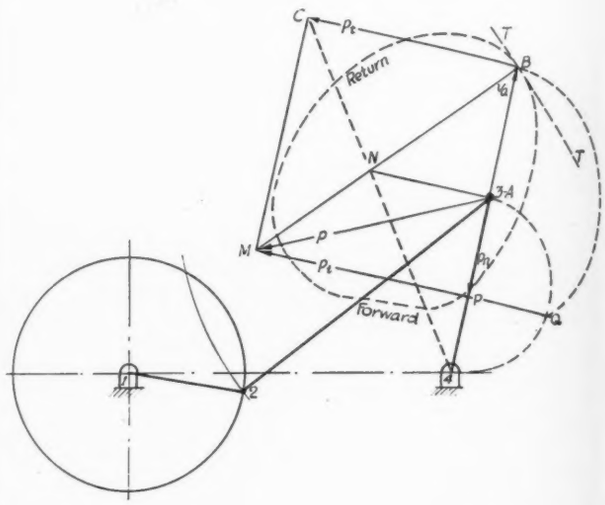
already given in the previous article. Point A has for instance the velocity $v_a = AB$. Now the tangents to the actual path (vertical to $A4$) and the normal to the diagram of velocities NB, are drawn; the latter is obtained through drawing first the tangent TT. The normal intersects the tangent to the path at N. $4N$ is connected by a line and this is intersected by a parallel to AN at B, giving point C. BC is already the tangential acceleration p_t which has only to be transferred to A. In general the knowledge of the tangential acceleration is satisfactory, but the total acceleration can also be found quite easily by drawing the parallel to AB through C and extension of BN, giving M



as intersection: $AM = p$. As the parallel MP to BC yields $p_n = AP$, the accuracy of the construction can be checked by drawing the half circle over $4A$ and intersecting it by a circle from A with $AB = v_a$, yielding Q (geometrical construction for $p_n = v_a^2/a$). The former construction is correct if Q lies on the extension of MP.

This construction does not yield a result for the end positions of the swinging lever and here the algebraic, graphical solutions or more complicated geometrical constructions seem to be necessary.

—PAUL GRODZINSKI
London, England

" . . . saves one step"

To the Editor:

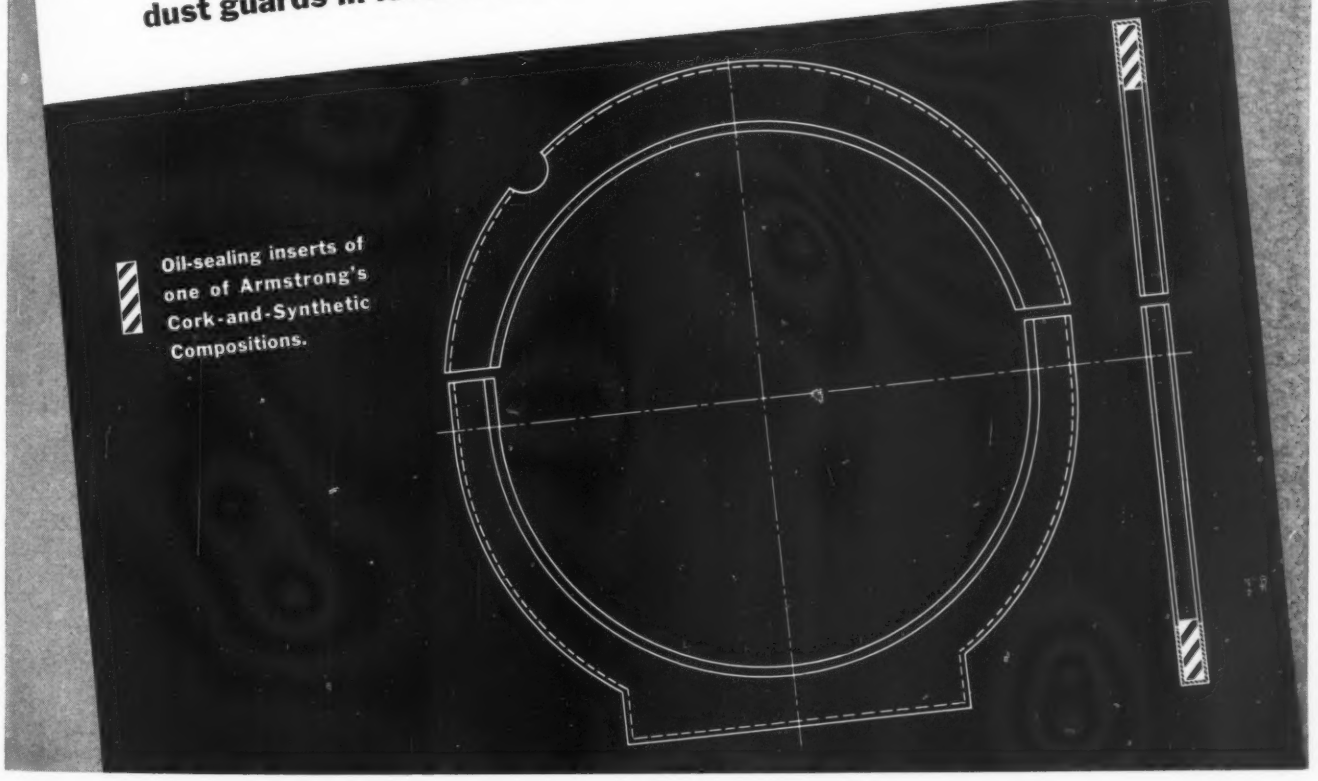
Referring to Mr. Grodzinski's letter describing Gruebler's graphical method of analyzing accelerations in a four-bar linkage, I am sure that this method will be of considerable interest to your readers. Basically, this construction involves a graphical differentiation of the velocity curve of point A with respect to the displacement path of A and requires the following relationship between the displacement, velocity and acceleration scales: Acceleration scale = (velocity scale)^2/displacement scale.

It may be observed that I stated in my article that the velocity-time curve may be differentiated graphically to produce an acceleration curve. Mr. Grodzinski does exactly this and he does it with one less step than is required by usual methods.

—H. A. BOLZ
Purdue University

CASE HISTORY No. 265 FROM OUR GASKETS FILE

PROBLEM: To find a better oil-sealing insert for cellar dust guards in locomotive and tender journal boxes



TO prevent a "hot box," the oil inside a locomotive journal box must be *sealed in*—and dust and moisture *sealed out*. The dust guard which a prominent locomotive manufacturer uses for this job is a brass retainer having a resilient insert, held against the axle by springs.

The manufacturer formerly used a leather insert, but found it was not wholly satisfactory. The oil gradually softened the leather and caused it to sag away from the running surface, leaving a poor seal. Moreover, grit tended to imbed itself in the softened leather. So he assigned to Armstrong the problem of finding an insert material which the oil would not soften, yet which would stay resilient enough to make a sure, lasting seal.

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Mathematics of Modern Engineering

Volume II (Mathematical Engineering), by Ernest G. Keller, Mathematics Staff Engineer, Lockheed Aircraft Corp.; published by John Wiley & Sons Inc., New York; 309 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

Second part of a three-volume series, this book covers engineering dynamics and mechanical vibrations, introduction to tensor analysis of stationary networks and rotating electrical machinery, and non-linearity in engineering. While to engineers this will appear to be a highly mathematical book, it nevertheless is an outcome of actual engineering experience and is written from an engineer's standpoint. This means that equal emphasis has been placed on the two processes of mathematical engineering, "set-up" and "solve". To set up in the form of equations the information which will determine the performance of engineering equipment is difficult, requiring engineering ability of a high order combined with a knowledge of mathematical physics. Continuing the method of approach used in Volume I of the series, the book shows by examples how these processes are applied to the solution of engineering problems.

□ □ □

Marine Engineering

Volume 1. Edited by Herbert L. Seward, Professor of mechanical and marine engineering, Yale University; published by The Society of Naval Architects and Marine Engineers, New York; 353 pages, 8 by 10¾ inches, clothbound; $6.00 postpaid in the United States.

First of a two-volume series, this book deals with the general principles of design and with main propulsion units. Chapters are included on procedure in general design, boilers, reciprocating engines, steam turbines, diesel engines, reduction gears, propellers and shafting, and materials and metallurgical engineering.

□ □ □

Aircraft Engine Design

By Joseph Liston, Associate Professor of Aeronautical Engineering, Purdue University; published by McGraw-Hill Book Co., New York; 486 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

Intended for young engineers with a background knowledge of general machine design but no experience in the field of aircraft engines, this book is a comprehensive review of conventional engine design practice. Information has been assembled from many different sources, chiefly

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concerning the design and selection of mechanical parts. The text, covering about two-thirds of the book, is arranged in logical sequence so that the reader may parallel his reading with design calculations of his own. The remainder of the book is made up of appendixes which include technical data on aircraft engines and engine parts, properties of aircraft engine materials, and useful design formulas.

After two introductory chapters covering basic requirements, possibilities and limitations and outlining the design procedure, the book takes up in turn gas pressure forces, analysis of the crank chain, analysis of bearing loads, design of reciprocating parts, crankshaft vibration and balance, crankshaft details and reduction gearing, cylinders and valves, valve gear, the crankcase, superchargers, and accessories.

□ □ □

Engineering Mechanics

By Frank L. Brown, Professor of Applied Mechanics, University of Kansas; second edition, published by John Wiley & Sons Inc., New York; 503 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

This new edition of a widely used text follows the same general plan as the earlier edition, but has been reset and furnished with new cuts and problems. Changes have been confined mostly to the method of presentation, emphasis being placed on relationships set forth as principles, rather than symbolically, as formulas. Explanations are unusually complete and more than twelve hundred problems are included, with answers to about half of them and worked solutions to many.

The book is divided into the conventional two parts—statics, and kinematics and kinetics—and covers the material usually included in engineering college courses.

□ □ □

Machine Tools in Aircraft Production

By R. R. Nolan, Superintendent of Tooling, Northrop Aircraft Inc.; published by Pitman Publishing Corp., New York; 158 pages, 5¼ by 8 inches, clothbound; available through MACHINE DESIGN, *$1.50 postpaid.*

With mass production now an essential part of the aircraft design picture, the appearance of this guide to the selection and application of automatic machine tools in the aircraft industry is welcome. Compact, practical, and illustrated with well-chosen photographs and drawings, the book is intended primarily for the vocational student or young mechanic, but should also be of interest to others in the production or design field.

Included are chapters on classification of the machine tools most important to the aircraft industry, aircraft machine shop, high-production and special machines, the toolroom, the sheetmetal shop, the hydraulic forming press, the drop hammer, the development and application of high-speed metal-cutting tools in aircraft, and general guide for the analysis of machine-tool requirements in aircraft production.

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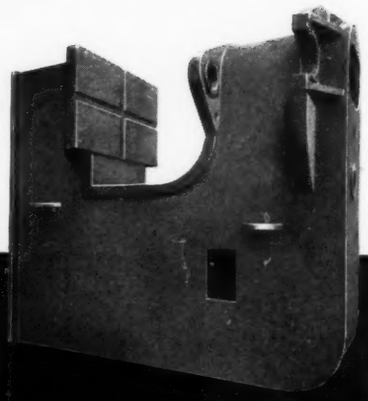
A Graver-welded Open Side Press Frame — 420 tons capacity. 10′ 9″ high — 9′ 2″ wide — 4′ 8½″ thick. Wt., 33,370 lbs.



GRAVER

Welded Construction ON AMERICA'S INDUSTRIAL FRONT

Industry's needs today are just as important as those of the boys on the firing line. But supplies and munitions are expendable, while industrial machinery must be built for today *and years to come.*

Take, for instance, this huge Press Frame welded by Graver. Here's 16½ tons of rugged strength and endurance, and though built to play a vital part in the Victory program, it will carry on with equal efficiency in producing the necessities of a peacetime world.

For the duration, our efforts will continue to be devoted to supplying those who are producing munitions and supplies for our armed forces. But when tomorrow comes, Graver facilities and experience will again be available for peacetime needs.

GRAVER

STEEL STORAGE TANKS · WELDED CONSTRUCTION · STRESS RELIEVING
X-RAYING · FABRICATED STEEL AND CORROSION-RESISTING PLATE
VAPOR CONSERVATION SYSTEMS · WATER SOFTENERS · CLARIFIERS
FILTRATION SYSTEMS · SEWAGE EQUIPMENT

GRAVER TANK & MFG. CO., INC.

4809-36 TOD AVE.
EAST CHICAGO, IND.
CABLE ADDRESS — GRATANK

NEW YORK
CATASAUQUA, PA
CHICAGO
TULSA

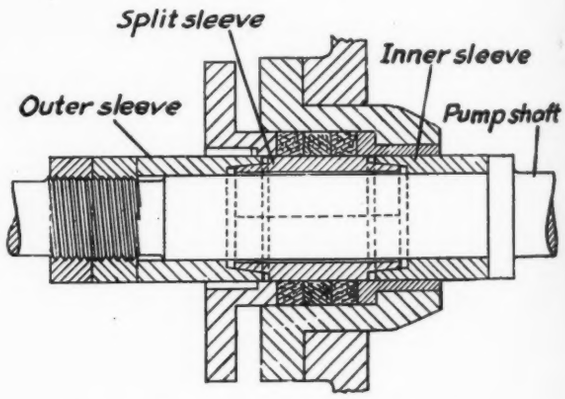
42-32-6

NOTEWORTHY PATENTS

Facilitates Renewal of Worn Sleeve

WEAR on rotary pump shafts, due to high packing pressure necessary for fluid-tightness, is commonly obviated by using renewable sleeves. Design of a sleeve requiring the minimum amount of replacement material and which can be installed without dismantling any parts of the pump other than the stuffing box glands is disclosed in a patent assigned to G. & J. Weir Ltd.

The split sleeve shown in the illustration is the only



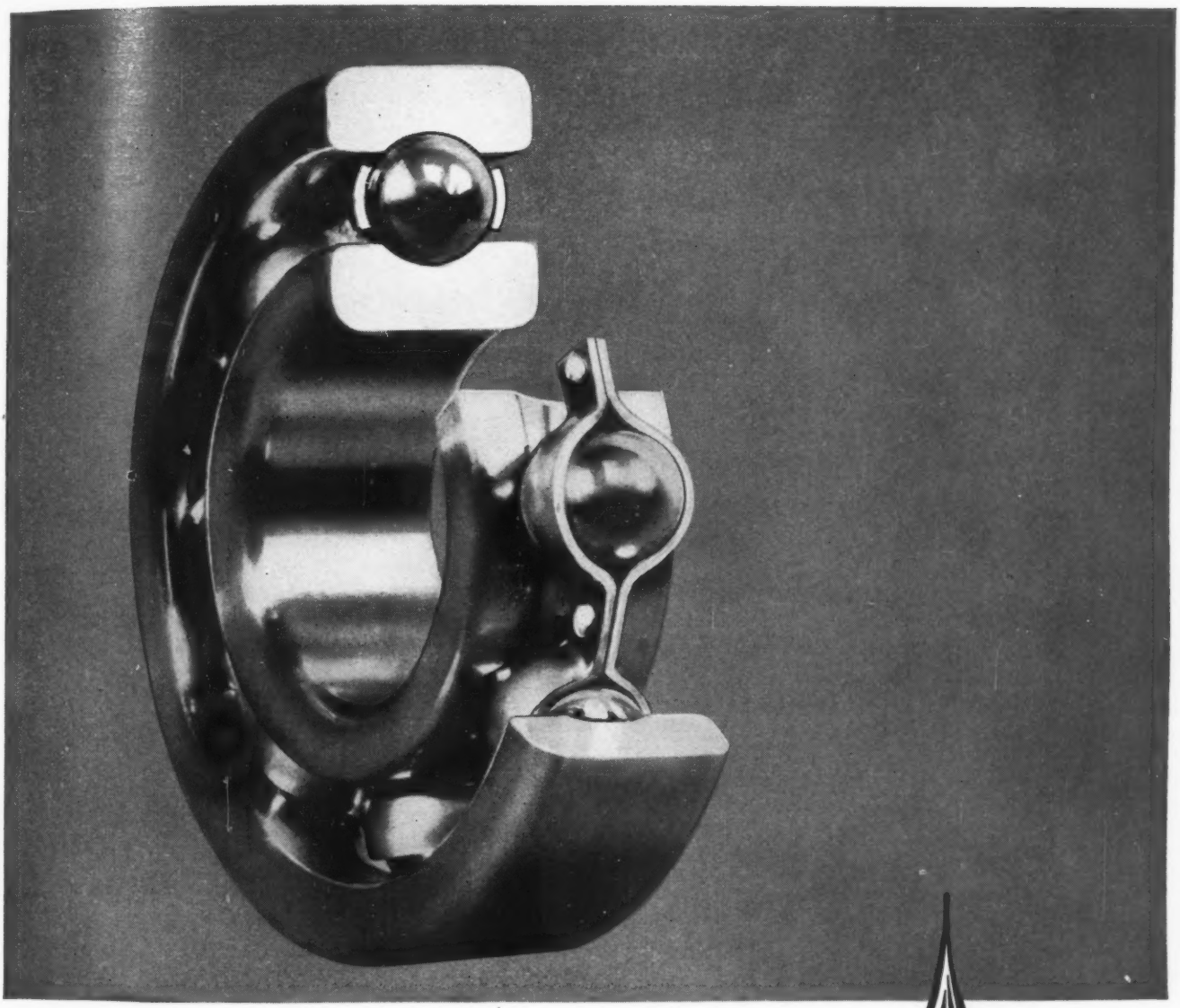
Split sleeve is easily replaced when worn

part that needs renewal. Machined with conical surfaces on each end, the split sleeve is gripped in the conical recesses formed in the solid inner and outer sleeves. Pressure for holding the sleeve is furnished by subjecting the assembly to axial compression between a collar on the pump shaft and a nut on the outer end. Replacement involves merely slipping the gland, nuts and outer sleeve clear of the assembly, removing the packing and substituting a new split sleeve for the worn one.

Damps Transverse Shaft Vibration

LOCAL periodic impulses at one or more places along the length of a multithrow crankshaft, tending to bend it, may cause transverse or beam vibrations. A vibration damper for diminishing such vibrations is covered by a patent recently assigned to General Motors Corp.

Due to local inclinations of the deflecting shaft, counterweights projecting at right angles to the shaft have a component of vibration in the axial direction. This is made use of in the design, as shown in the illustration, by drilling axial holes in the counterweights into which are inserted loosely fitting plugs or damping masses. These



Longer Life for Your Bearings

THROUGH PROPER LUBRICATION

Proper lubrication can greatly lengthen bearing life. In lubricating, avoid "too much . . . too soon" . . . as well as "too little . . . too late." You'll obtain longer service from your sturdy BCA Ball Bearings . . . which are now essential war equipment . . . if you observe the precautions at the right.

BEARINGS COMPANY OF AMERICA, LANCASTER, PA.

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS

Standardize on Standard Sizes

1. Use only neutral mineral lubricants.

2. When lubricating with grease, it is not advisable to have the housing more than one-half to two-thirds full. Too much grease may cause generation of heat faster than it can be dissipated by the surrounding housing.

3. While greasing, vent the grease chamber of housings that have shaft and bearing seals. Otherwise, excessive pressure may cause the destruction or blowing out of the seal.

4. When lubricating with oil, keep only enough in the housing so that the lowest ball dips in to one-half its diameter.

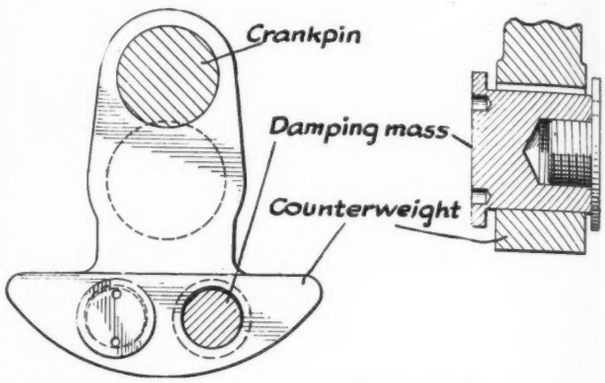
To get *tomorrow's* production *today* all machines building war materials are pushed to their capacities. Many such plants are equipping vital machinery with McGILL "Solidend" *MULTIROL* Bearings to increase efficiency, carry heavier loads and eliminate shut-down time losses.

BEARING DIVISION — 1450 No. Lafayette St.

McGILL MANUFACTURING COMPANY, INC.
VALPARAISO, INDIANA

are free to slide in the axial direction but tend to lag the vibration because of friction. The friction force exerted as they slide back and forth opposes the vibration. Flanges are provided on the damping masses to limit their axial motion.

At high crankshaft speeds the centrifugal force on the damping masses may become excessive, and the corresponding friction force so high that the mass cannot move. This condition may be obviated by the addition of an adjustable spring exerting a force which presses the damping mass inwards.



Friction of damping masses sliding axially in clearance holes opposes transverse vibration of shaft

While the weights of the damping masses constitute a part of each counterweight serving to balance the crankshaft, their weights do not affect the natural frequency of free transverse vibration. It is therefore apparent that the arrangement described enables the natural frequency of transverse vibration to be raised if necessary to avoid resonance while retaining the necessary mass in the counterweight for counterbalancing purposes.

Aids Renewal of Worn Clutch Linings

RELINING of conventional cone clutches is necessary whenever the wear has become so great that no further axial movement can take place without metal to metal contact. Because of the small cone angle this may happen with a relatively small amount of wear, and the friction lining material which must be discarded amounts to a considerable percentage of the original material. Conservation of material and simplicity of replacement are objects of a design covered by a patent assigned to The Marion Steam Shovel Co.

In one form of the design, shown in the illustration, the friction lining is made up of a series of annular laminated segments bolted to the driven member. When new, the lining has the appearance shown at left. After the limiting permissible wear has occurred the lining appears as shown at right. The lamination at the small end is then removed and a new lamination inserted at the large end, after which the lining is restored to its original appearance as shown in the left hand view. Each segment, of which there may be several around the circle, is held in place by two or more connecting pins.

While the illustration shows a double conical clutch surface, laminated segments may equally well be applied

Aid on wartime tool steel problems

Top speed war production demands TOOLS — *more* tools than dreamed of in peace time — *new kinds* of tools for new war time jobs. The tool industry is tackling this tremendous task short of skilled tool makers and restricted by shortages in their choice of steels.

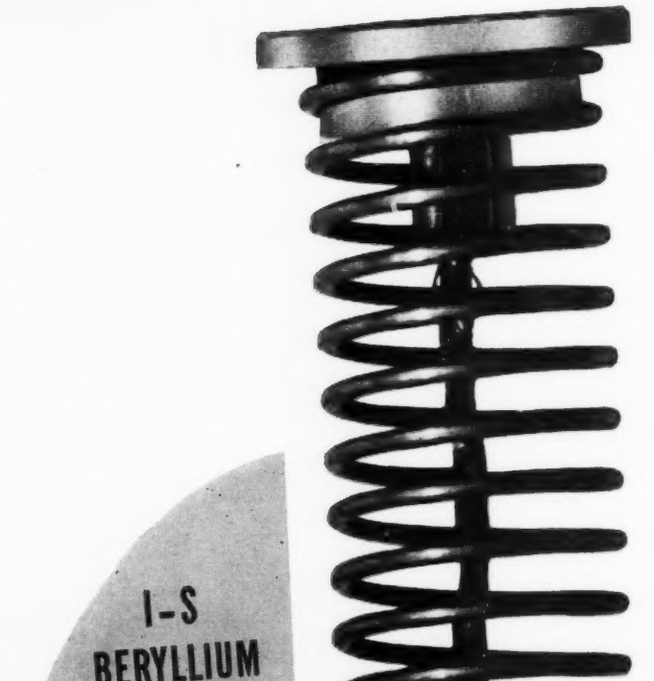
Solutions to these new problems are being worked out every day by the tool industry. Frankly, we don't have all the answers but our contacts with American tool makers determined to win this war puts us in a position to assist you in finding solutions to some of the particular problems that may be facing you.

On your problems of steel selection and treatment of tool steels, we would be very glad to have you get in touch with us. For your convenience, we are listing below the addresses of our district offices.

COPPERWELD STEEL COMPANY · WARREN, OHIO

COPPCO TOOL STEELS

BUFFALO	1127 Liberty Bank Building	Washington 7283
CHICAGO	122 S. Michigan Avenue	Harrison 1411
CLEVELAND	1158 Union Commerce Building	Cherry 1326
DETROIT	7-251 General Motors Building	Trinity 1-1760
NEW YORK	117 Liberty Street	Cortlandt 7-8314



I-S BERYLLIUM COPPER BRUSH SPRINGS

Reduced loss of tension with brush wear.

Safe at 300 deg. F.

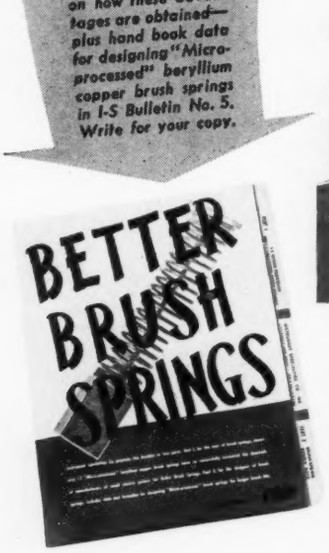
28% conductivity.

Closer tolerances eliminate need for necked down ends.

No set or drift.

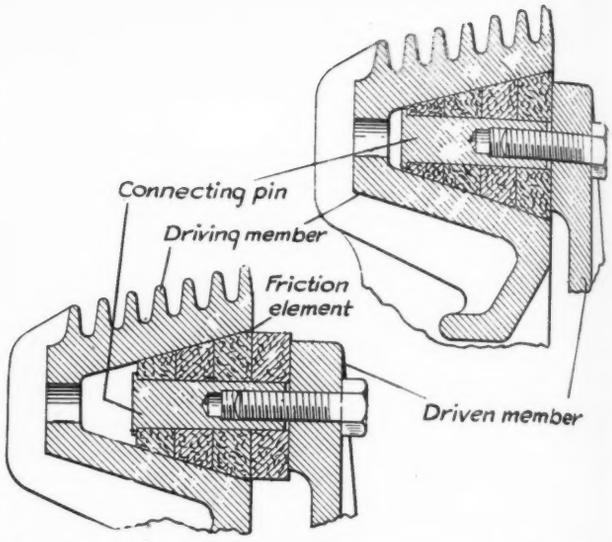
GET THE FACTS

on how these advantages are obtained—plus hand book data for designing "Micro-processed" beryllium copper brush springs in I-S Bulletin No. 5. Write for your copy.



Specialization telescopes time. Instrument Specialties Company has perfected beryllium copper brush spring design and production by the development of "Micro-Processing" — the only method by which all of the physical and electrical properties of beryllium copper are successfully controlled to meet the individual requirements of every order regardless of quantity.

INSTRUMENT SPECIALTIES COMPANY
DEPT. C LITTLE FALLS, NEW JERSEY



Friction elements are laminated circular segments. Left view shows condition when new, right view when worn

to clutches having only a single conical surface. In such a case the segments are cylindrical on the inside radius, fitted over the driven member and held in place by a flange.

This Jeep Really Flies

DESIGNED to be the "eyes upstairs" of the artillery, tank corps, cavalry, and infantry, the Stinson L-5 Sentinel is a veritable flying jeep. Like its counterpart on the ground, which can cover almost any kind of terrain, the new plane is designed to go wherever ground troops go, to get in and out of a cow pasture, or to plunk itself down on a highway.

Fuselage is welded steel tubing while the wings and tail surfaces are wood. To conserve vitally needed materials, the plane was redesigned just before it was put in production, eliminating almost 20 per cent of the steel and 70

per cent of the aluminum in the original design. To absorb landing shocks on rough terrain, the stroke of the spring-and-oil shock absorbers has been lengthened to approximately double that of the conventional types. Powered by a 190-horsepower horizontally opposed Lycoming engine, the ship has a 34-foot wing span, is 24 feet in length, and weighs 2100 pounds.

facts we learned from boiler tubes can step up your production

Babcock & Wilcox Tube Company developments in the manufacture of seamless steel tubing now permit boilers to operate at 2500 lb. per sq. in. pressure at 1100 F. and higher. The same men, working with the same care, in the same mill that produced those tubes, also produce B&W Seamless Steel Mechanical Tubing. B&W Seamless Mechanical Tubing can be used as machining stock or for structural members in scores of applications.

Drilling and boring operations are simplified, steel is saved and the chip-disposal problem is reduced. Man-*hours* you spend now in re-designing or re-tooling for tubing may soon be saving you man-*days* in production.

When you do turn to tubing, remember that B&W Seamless Mechanical Tubing is produced in a specialty-tube mill where men and machines regularly work to far more difficult specifications than you will require. You can logically expect the best mechanical tubing to come from B&W.

TA-1222

B&W Seamless Steel Mechanical Tubing is available in a wide range of sizes, in carbon steel, National Emergency steels and S.A.E. alloy steels, hot finished or cold drawn, in a variety of tempers. Details in Bulletin TB-319, yours free on request.

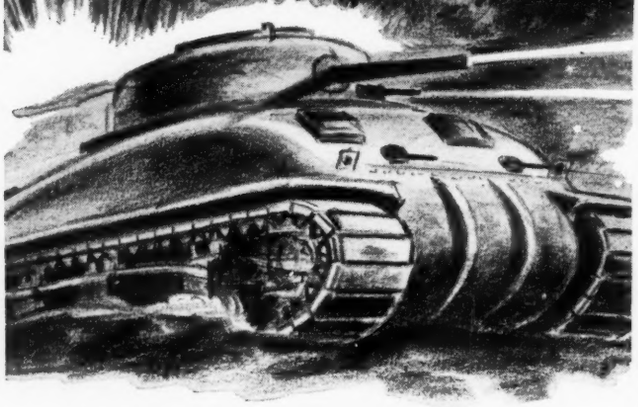
BABCOCK & WILCOX TUBES

HOT FINISHED
COLD DRAWN

ALLOY STEELS
CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY
BEAVER FALLS, PA.

Machine guns can't dent it..

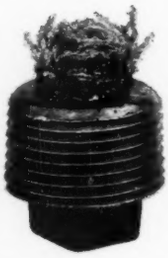


..but tiny steel particles could STOP it!

TOUGH as they are, tanks could be put out of action by the abrasive, grinding action of steel chips and particles in the gear, bearing and engine lubricants. Fortunately, Uncle Sam's battle wagons are practically immune to this kind of damage, because they are now MAGNETIC PLUG-equipped.

Magnetic Drain Plugs contain a powerful permanent magnet which attracts and holds iron and steel particles which are constantly formed by ordinary wear.

Removal of these particles eliminates one of the most common causes of excessive wear.



MAGNETIC PLUGS are now available only for essential war equipment. Limited quantities of samples are available, however, for testing in all types of products. Write for full details and sample offer.

LISLE CORPORATION, Box 1003, Clarinda, Iowa

Magnetic DRAIN PLUGS

MEN OF MACHINES

AMONG the recent appointments at Allis-Chalmers Mfg. Co., Milwaukee, is that of J. Frank Roberts, replacing Dr. William Monroe White, internationally known engineer and manager of the hydraulic turbine department. Mr. Roberts was formerly head hydraulic engineer of TVA. Back in 1919 he joined Allis-Chalmers as a graduate engineer in the company's training course. He became office manager in the hydraulic department and remained in that capacity until 1927 when he left to join a Canadian public utility. In approximately ten years he joined the Tennessee Valley authority, which position he has left for his present post.

Dr. White, who is retiring after thirty-one years with Allis-Chalmers, has engineered some of the largest hydroelectric installations in the world, including Niagara Falls, Boulder Dam and TVA. He joined the company in 1911 from the I. P. Morris department of the Wm. Cramp & Son Ship & Engine Building Co. Dr. White is credited with about 50 patents on his many inventions. His work, both as an engineer and an author of engineering treatises, is widely recognized. In 1930 Tulane university—his alma mater—presented him with an honorary doctorate

HOW TO SPEED PRODUCTION WITH

SAFETY GLASS

For years you've enjoyed the greater protection of Safety Glass in your automobile. Now, there are many ways you can put this same glass to work in your factory to help speed production for victory.

In scores of plants today, you'll find machine tools equipped with eye shields made of Safety Glass. Workers are not only given added protection from flying particles, but also unrestricted vision for precision jobs. Operators feel a greater sense of security, they see better, their jobs go faster.

The same advantages resulting from better vision and greater protection result when windows of crane cabs and steel mill pulpits are glazed with Safety Glass. In foremen's quarters, on factory doors—wherever both vision and greater safety must be considered—you'll find a practical and profitable use for Safety Glass.

Safety Glass is only one of many Libbey·Owens·Ford products which are of vital interest to industry in these critical days. In addition to its many applications in equipment required by the armed forces, glass is occupying an increasingly important place in the thinking of manufacturers who are seeking a replacement for priority-scarce materials for use in their products.

Just Consider These Facts About Glass

It has many qualities not found in combination in any other material. It can be furnished, thanks to new techniques perfected by Libbey·Owens·Ford, in bent shapes never before thought possible. It can be made transparent, translucent or opaque. It can be polished or coated. Its surfaces are enduring and acid-resisting. It is an electrical insulator. It can be made strong, highly resistant to impact and to thermal shock. It can be color-clear, or colorfull. And it has a wide range of other physical and chemical properties that fit it for use for many special purposes.

Quite likely in the complete line of Libbey·Owens·Ford products you will find a type of glass that will meet your production requirements. And next time you walk through your plant make a mental note of the places where you can profit by the added protection of Libbey·Owens·Ford Safety Glass. Write Libbey·Owens·Ford Glass Company, 1362-A Nicholas Building, Toledo, Ohio.

L O F

LIBBEY·OWENS·FORD

QUALITY *Flat Glass* PRODUCTS

Do You Need Fractional H.P. Motors to Meet a Government Contract?... We are now in a position to supply PILOT Fractional H.P. Motors ranging from 1/500 to 1/15 H.P. to all manufacturers who can furnish satisfactory priority ratings.

PILOT MOTORS have established an enviable reputation for efficient, dependable performance in hundreds of applications. They *can* and *will* do the same for you!

Write Today for Bulletin P-2341 giving complete details about these low-cost, easy-to-install Fractional H.P. Motors.

F. A. SMITH MANUFACTURING CO.
201 DAVIS STREET
ROCHESTER, N. Y.

PILOT DAN SAYS: *"Get in the Scrap—with your scrap! Every pound of waste metal will help pound the Axis into submission!"*

Pilot MOTORS
FRACTIONAL · H · P · MOTORS

of science, and in 1940 he was named a Modern Pioneer. Dr. White is a member of the American Society of Mechanical Engineers, the American Society of Engineers and the Franklin institute, among others.

♦

VETERAN in the heating and air-conditioning industry, Allen P. Livar has been appointed chief engineer of the Airtemp division, Chrysler Corp. Since 1937 he has served as chief heating engineer and has made outstanding contributions to design, manufacturing methods and field applications. Before joining the Airtemp organization, he designed the Richvar radiator produced by Richmond Radiator Co. Mr. Livar, a native of Nashville, Tenn., graduated from Georgia School of Technology with a mechanical engineering degree, specializing in refrigeration. He then joined the United States Navy with the rank of Ensign, assigned to engineering duty. After the war, he was connected with the United States Steel Corp., in charge of assembling 3000 horsepower marine engines. Mr. Livar entered the heating industry when he joined American Radiator Corp. in the company's Birmingham plant. In 1924 he served Pierce, Butler & Pierce, and two years later he joined the Trane Co. He became associated with Richmond Radiator Co. in 1932, as vice president in charge of sales and chief engineer. When this company was absorbed by Reynolds Metals Co., he went to Reynolds as general manager of the air conditioning division, where he remained until he joined Chrysler Airtemp as chief heating engineer in 1937.

♦

PROF. E. L. MIDGETTE has been retained as consultant for American Engineering Co., Philadelphia. He remains at his post as professor of machine design at Polytechnic Institute of Brooklyn.

♦

ELMER BIMBERG, formerly chief engineer, has been named plant manager of Zenith Carburetor division of Bendix Aviation Corp., Detroit.

♦

E. E. LUNDBERG, vice president in charge of engineering, has been made director of Briggs Mfg. Co., succeeding Howard Bonbright.

♦

CAPT. C. A. TREXEL, director of planning and design, and A. AMIRIKIAN, design engineer, Bureau of Yards and Docks, Navy Department, Washington, jointly won the James F. Lincoln Arc Welding Foundation grand award; winning paper dealt with arc welding of caissons for naval dry docks.

♦

B. O. AUSTIN of Westinghouse has been appointed control section engineer, with responsibility for design and

MORE AND MORE *Production*
"ON THE WAY"
With Microfinished Precision

Stock removal, up to .060" or .075" at rates as high as 65 cubic inches per hour, to generate correct size, straightness and roundness, is the dominant feature of Micromatic Honing. The Micromatic Honing Process (available with Automatic Microsize for bores up to 2" in diameter and 6" long) will generate uniform size within .0002" to .0005"—bore accuracy within .0001" to .0002"—removing sufficient stock to get the desired results. Applications to ordnance have included gun tube honing, before and after rifling —gun case honing—internal honing of recoil cylinders—external honing of recoil pistons—reconditioning in placement of worn gun tubes up to 16" caliber.

Typical gun barrels regularly honed in production by Micromatic equipment include 50 caliber machine guns—20 millimeter cannon, 37 millimeter cannon, as well as other and larger calibers up to and including 16" and 18", and from 30" up to 75 feet in length.

★

External honing of recoil piston rods generates accuracy within .0001" to .0003" and any desirable finish.

★

Recoil cylinders Micromatic honed. Circular illustration—looking down the bore. The regularity of the eccentric rings (a phenomenon of smooth surface finish) evidences round and straight accuracy generated in typical ordnance applications within .0005" to .0007" as measured with both star and electric gauges.

★

Typical of tooling used for honing large caliber guns is this hydraulically actuated tool. This tool was designed for bores 18" in diameter, 62 feet long.

MICROMATIC HONE CORPORATION
1345 E. MILWAUKEE AVE. DETROIT, MICHIGAN

to your production machines

LEWELLEN

Variable SPEED CONTROL

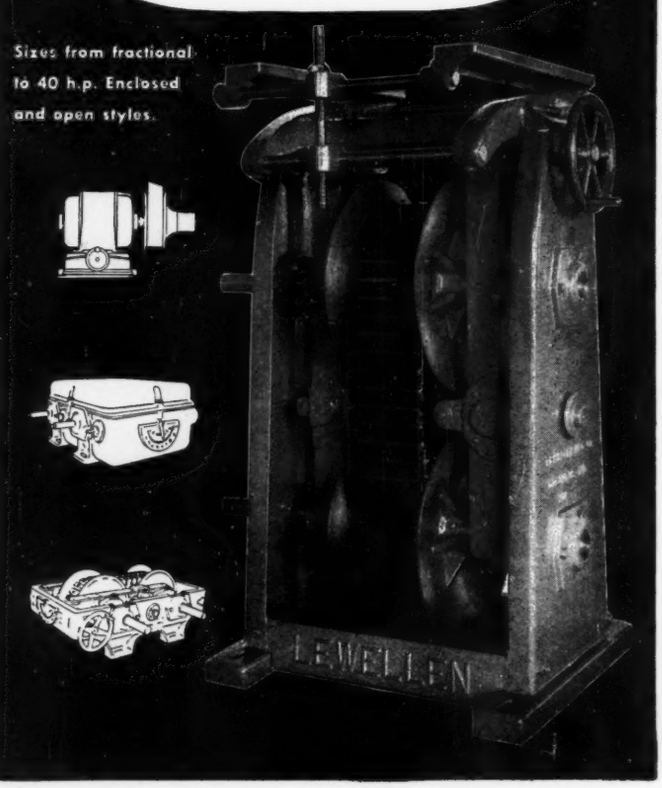
TRANSMISSIONS • MOTOR PULLEYS

● Often results are amazing when Lewellen Speed Control is applied to a production machine! Consider what the "right speed at the right time" will do for your machines. You can count on product uniformity because production speed can be adjusted to meet varying plant conditions and lack of uniformity in materials. Spoilage is reduced to a minimum. You get maximum machine output and uninterrupted service—no belts or gears to change.

Now that your production problems are so vital and because Lewellen Speed Control means so much to any fixed-speed machine, old or new—we urge you to let us help you. Why not Wire, Phone or Write, TODAY?

LEWELLEN MANUFACTURING CO.
COLUMBUS, INDIANA

Sizes from fractional to 40 h.p. Enclosed and open styles.



development of certain war equipment at the Lima, O., small motor division of the company.

♦

A. G. YORK of Watson-Stillman Co., Roselle, N. J., has been made a member of the valves and fittings committee of the War Production Board.

♦

WILLIAM R. TRACY, chief of the Farm Machinery and Equipment branch, War Production Board, has resigned to accept a position in the Motor Transport division, War Department. Mr. Tracy was vice president of Pontiac Motors division.

♦

ROBERT A. MILLER has been appointed head of the new engineering division of Agerstrand Corp., Muskegon, Mich. He formerly was assistant chief tool engineer, hoist division, Willys-Overland Co.

♦

DR. C. F. BURGESS has recently been awarded the Edward Goodrich Acheson medal and $1000 prize by the Electrochemical Society, which is the highest award in the field of electrochemistry. He is the inventor of the Burgess battery.

♦

DR. N. E. WOLDMAN will head the newly organized aluminum and magnesium division of the American Foundrymen's association. Dr. Woldman is chief metallurgical engineer, Eclipse Aviation division, Bendix Aviation Corp., Bendix, N. J.

♦

H. V. COES has been elected president of the American Society of Mechanical Engineers for 1943. He is vice president of Ford, Bacon & Davis Inc., New York.

♦

STEVENS H. HAMMOND has been named executive vice president and will also serve as chief of the executive staff at Whiting Corp., Harvey, Ill.

♦

DESMOND SPRAGUE, mechanical engineer, Sprague Specialties Co., North Adams, Mass., has become a member of the engineering staff of the propeller division, Curtis-Wright Corp., Caldwell, N. J.

♦

C. E. WERNER has resigned from SKF Bearings Inc. to become chief engineer of the J. W. Hewitt Machinery Co., Neenah, Wis.

♦

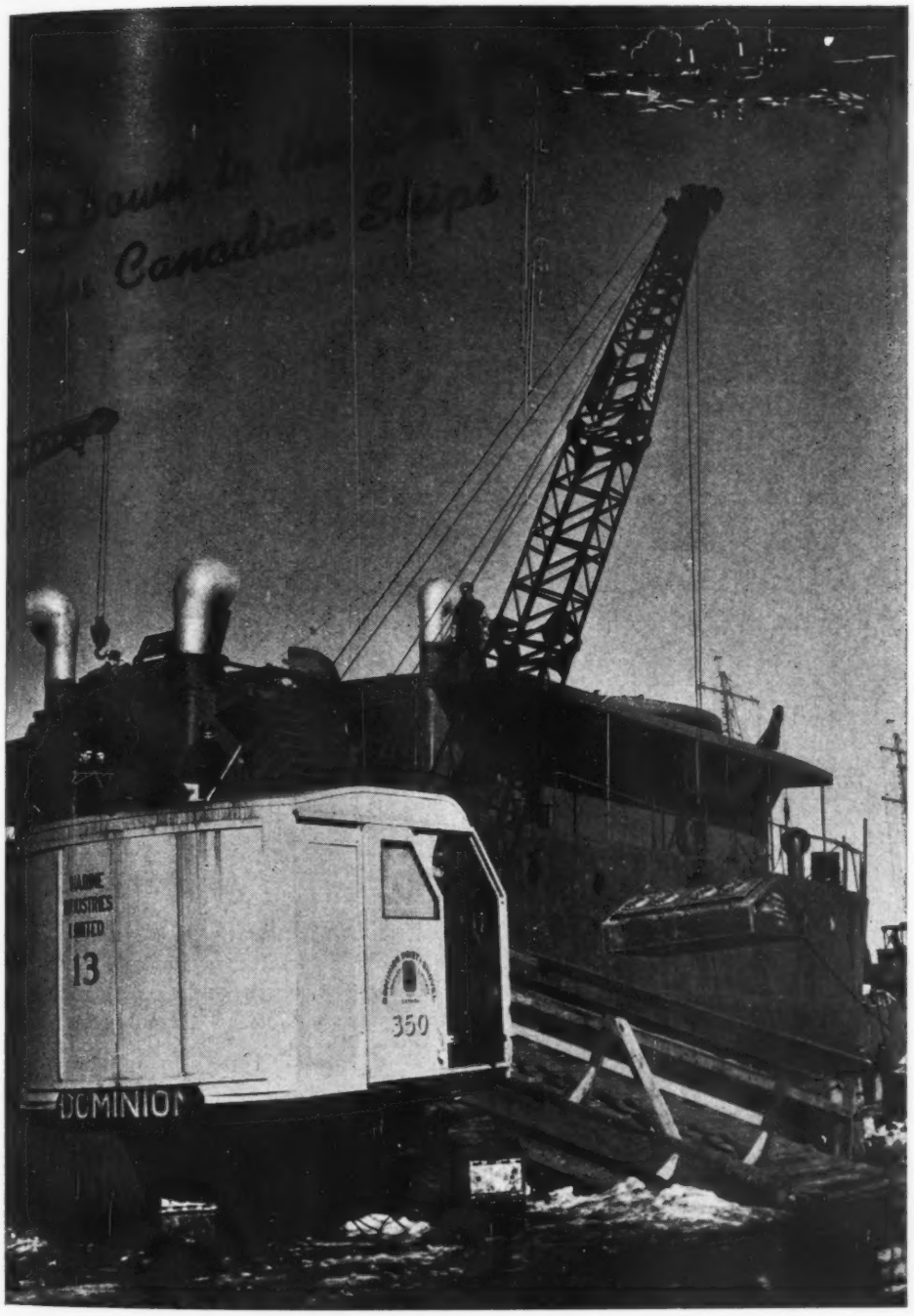
HERMAN E. BAKKEN, assistant director of research, Aluminum Research Laboratories of Aluminum Co. of America, New Kensington, Pa., has been made associate director.

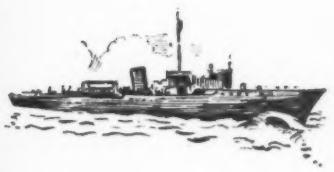
♦

FRANK EDWARD FLYNN has been elected president of the Association of Iron and Steel Engineers for 1943. Connected with Republic Steel Corp., Warren, O., Mr. Flynn has had a long association with the steel industry.

♦

A. W. THOMAS, previously connected with the construction machinery division of Chain Belt Co., Milwaukee, has been made consultant for the construction machinery division of the War Production Board.

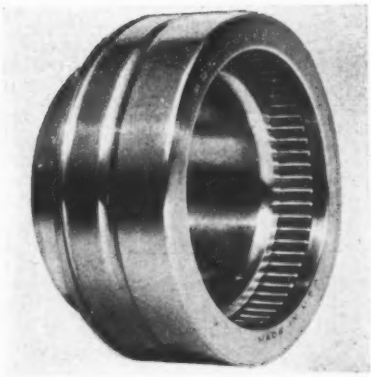




RBC NEEDLE BEARINGS

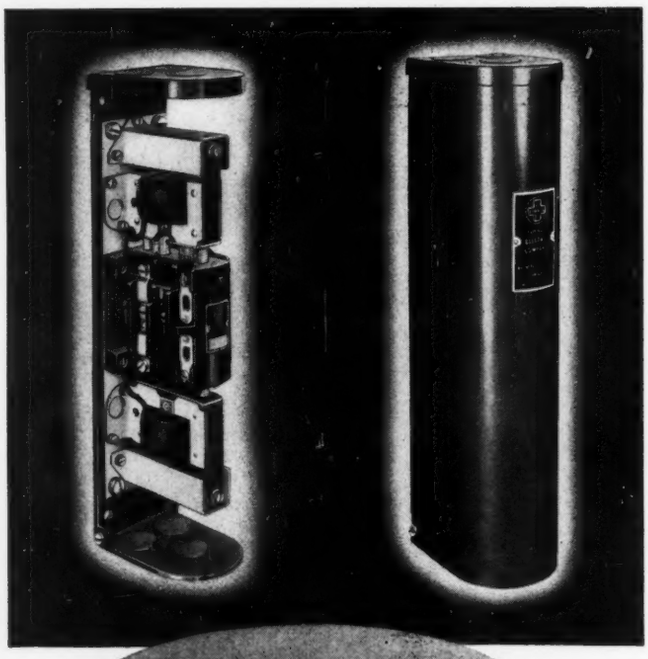
help speed Canada's Ship Building Program

RBC Bearings are found on another production front, this time in a Canadian shipyard which is building Corvettes and Minesweepers to keep our vital sea lanes open. On this Dominion Hoist & Shovel Co. Model 350 Crane, RBC CYCLOPS Needle Bearings are given the important job of accurately meshing the gears of the horizontal reverse shaft assembly. RBC Bearings are distributed in Canada exclusively by Canadian SKF Co., Ltd., Montreal, Toronto, Winnipeg and Vancouver.



ROLLER BEARING CO. of AMERICA

TRENTON . . . . NEW JERSEY



Improved FURNAS MAGNETIC REVERSING SWITCH

★ The Furnas Five Horsepower Magnetic Reversing Switch was the first to be designed as a single unit, instead of being made up of two separate contactors.

This design made it possible to reduce the Switch to a very compact size without reducing horsepower, quality or ruggedness.

This improved Switch is suitable for the most severe plugging duty and has an exceptionally long life. The action is fast, due to light weight of moving elements.

★ Coils are so well designed that Switch can be operated 500 reversals per minute without undue heating of coils. Mechanical life of Switch is well over 5,000,000 cycles. Can be furnished for panel mounting or with standard or watertight enclosure.

FURNAS ELECTRIC COMPANY

SPECIALISTS IN DRUM CONTROLLERS

For complete information, ask for Furnas Bulletin 4216. Furnas Electric Co., 439 McKee St., Batavia, Illinois.

BATAVIA ILLINOIS

Redesigned Gun

(*Continued from Page* 88)

each part was closely controlled and the specifications for physical properties were established with these chemical limitations in mind. In TABLE II are shown the physical property requirements for the chassis parts, and in TABLE III the chemical analyses of the materials used.

All the welds shown in the illustrations are single bead, plain-carbon steel, covered electrode, metallic-arc deposits. For the frame proper, a low-carbon steel back-up strip is employed with little scarfing or other preparation of the welded joint required. Pickup of alloying elements from the alloy plate during welding assures weld metal physical properties comparable with the values characteristic of the plate material. Check tests give results similar to those shown in TABLE I.

Costs Are Compared

Comparable total labor costs for riveted and for welded constructions were developed for the chassis. Estimates indicated that 282 man hours would be required for riveted construction and only 218 for welded construction. A charge of $.004 per pound of metal for stress relieving was applied against the welded construction total labor charge. In these preliminary estimates, assumption was made that the material costs would be about the same and no effort to develop relative costs in terms of material differences was made. Based on an hourly rate of $1.20, this preliminary estimate indicated that a saving of $76.80 per chassis could be effected if welded construction were adopted. Actual costs of welded construction reported during May are shown in TABLE IV in comparison with the estimated welding costs.

Top Carriage Redesign Also Stronger

After the advantages of the welded construction applied to the chassis had been developed, a study of the top carriage indicated that a welded design would be both cheaper and stronger. The redesigned top carriage weighs 300 pounds in comparison with a weight of 264 pounds for the foreign model of riveted construction and a calculated weight of 317 pounds if riveted and of equivalent thickness. This top carriage is made by attaching the uprights to the turntable which is fabricated by the employment of pressed and formed parts welded together. These parts are formed from the same quality steel used in the plate construction of the chassis. The high-strength, low-alloy steel plates forming the upright box section are punched, placed in welding jigs, and edge and slot welded together. In *Fig.* 7 is shown a photograph indicating the general design features employed in the fabrication of the foreign model top carriage. The different angle of mounting and the different bearing construction employed for the breech connection are apparent as are the slot type welds used in joining the side plates to the internal stiffeners. The

(*Continued on Page* 178)

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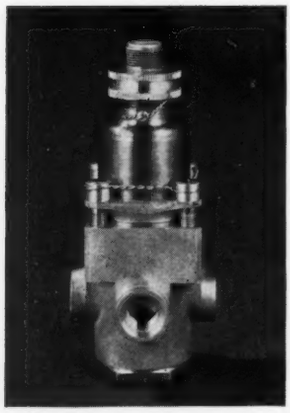

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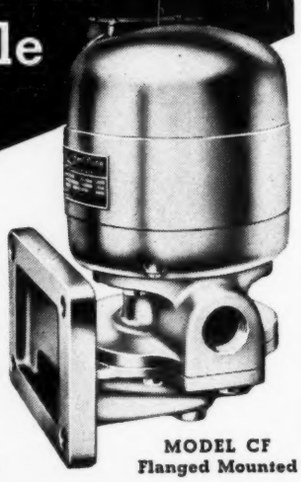

MODEL CF
Flanged Mounted

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WEST SPRINGFIELD, MASS.

(*Continued from Page* 174)

physical properties and chemical analyses of the steels used in the fabrication of the top carriage are presented in TABLES V and III.

The preliminary estimated cost comparison for the riveted top carriage and actual costs for the welded one are shown in TABLE VI.

The elevating arc is mounted at the bottom of the breech and engages a gear arrangement attached to the top carriage which permits the gun to elevate, as previously mentioned, through an arc of minus 5 degrees to plus 90 degrees. *Fig.* 8 illustrates the two designs. Physical properties and chemical analyses of the steel parts used in the welded construction are shown in TABLE VII and in TABLE III.

Weight Saved in Elevating Arc Sector

To eliminate cracking and to minimize distortion as a result of welding, all welds are staggered during deposition. This precaution has been necessary particularly in view of the use of heat treated WD X4130 steel for the gear itself. The gear sector is stress relieved at 1150 degrees Fahr. after welding and then machined. The same steel thickness is used in both the riveted and the welded sectors and this part offers a direct comparison as to the weight advantage of welding where additional strength is not required. The riveted construction because of the presence of rivets weighs 42 pounds or 3½ pounds more than the welded sector. Such a weight advantage would have been common to most of the weldments in comparison with the riveted construction, had the same steel thickness been maintained. Preliminary estimates showed a welding cost of $2.11 each for the welded gear sector in comparison with a cost of $2.96 for assembly of the riveted construction. This amount included cost of stress relieving the weldment, which cost is not involved where riveting is used. The actual welding cost for the gear sector is $1.61 each, the lowered cost being due to more efficient handling and more rapid welding than had been estimated.

Castings Welded to Tubing

Axles of the foreign models were forged by upsetting the ends of solid steel bars and then machined as indicated in *Fig.* 9. Such a method of fabrication is relatively expensive, needlessly wasteful of material and slow in production. The axles used on the redesigned carriage are fabricated, employing WD 1035 tubing, cold drawn and finish annealed, to which cast steel heads are welded. These steel castings are purchased in accordance with Federal Specification QQ-S-681, Class 4, which requires a yield strength of 53,000 pounds per square inch minimum, 85,000 pounds per square inch tensile strength, 22 percent elongation, and 35 percent reduction of area. The chemical analysis of the cast heads is shown in TABLE III.

Weld joints are prepared by machining before welding. The axles are positioned and welding is accomplished by using ¼-inch covered electrode, carbon-molybdenum steel rods. Estimates indicated that material and labor costs for an axle as made in the foreign manner would be

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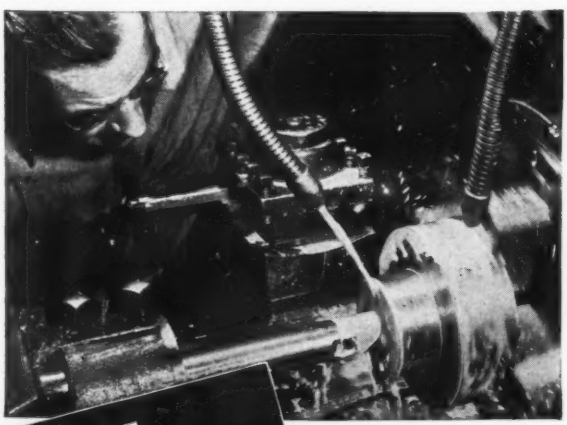

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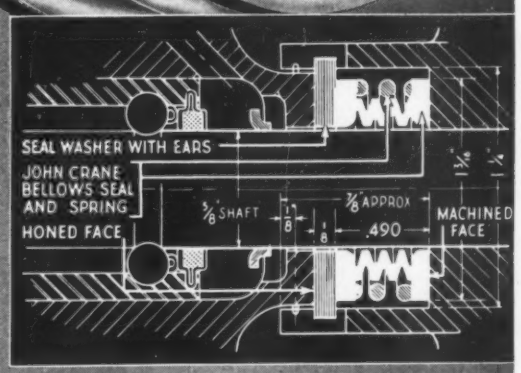

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$110 as contrasted with $42.08 for the tube and welded construction. Close-up views of the forged and of the welded constructions are shown in *Fig.* 9.

Many other small parts used on the gun carriage were redesigned for welded construction. The foot plates seen in *Fig.* 3 are another example of the completeness of the redesign for welded construction. The plates are attached to the four jack screws which are used to support and level the gun carriage while in firing position. A cost advantage of $.15 per plate in favor of the welded construction has been realized.

Another small part redesigned to take full advantage of welding is the gun stay or support which holds the gun tube in a rigid position during travel. This gun stay is discernible in the illustrations of *Fig.* 1. Welding is also employed in the fabrication of the equilibrator tubes, the draw bar and the carriage platform. The English model also used welding in the fabrication of these parts.

Weight Savings Are Summarized

In TABLE VIII is shown a summary of the weights for the important redesigned welded sub-assemblies, the comparable weight for the English model and the calculated weight of a riveted design having the same metal thickness as are present in the welded carriage.

In view of the nature of many of the sub-contracts, it is not possible to show in a definite way the money savings that have resulted from the employment of welded construction. From the information now at hand, the indicated saving is approximately $160 per gun carriage. This saving appears large until it is realized that the cost of materials, and the cost of the close machine work required on so many parts which are in no way influenced by the welded design, makes the actual saving rather small in terms of the total cost of the gun carriage.

TABLE VIII
Weight Comparisons

Part	Welded (lb.)	English-Riveted (lb.)	Calculated-Riveted (lb.)
Chassis	1084	824	1155
Top Carriage	300	264	317
Gear Sector	38.5	42	42
Front Axle	114	97†	121
Rear Axle	114	84†	108
Stake (4)	21.5	18	22
Foot Plate (4)	9.5	7.5	10
Gun Stay	60.5	58.5	62

† As previously explained, these parts are not riveted but forged.

In times as momentous as these, cost in itself cannot be a deciding factor in the determination of a particular Ordnance design. Speed of production and efficiency and reliability during field operation are of greater importance. Several design changes were incorporated in the gun carriage to improve operation and to increase production. In achieving these results, the most important change was the conversion from a riveted to a welded construction.

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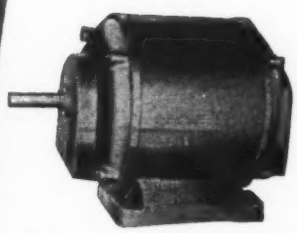

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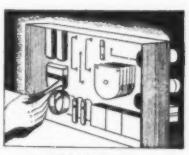

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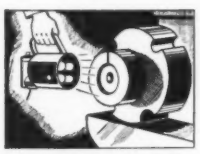

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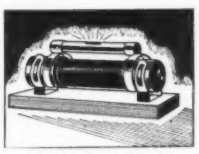

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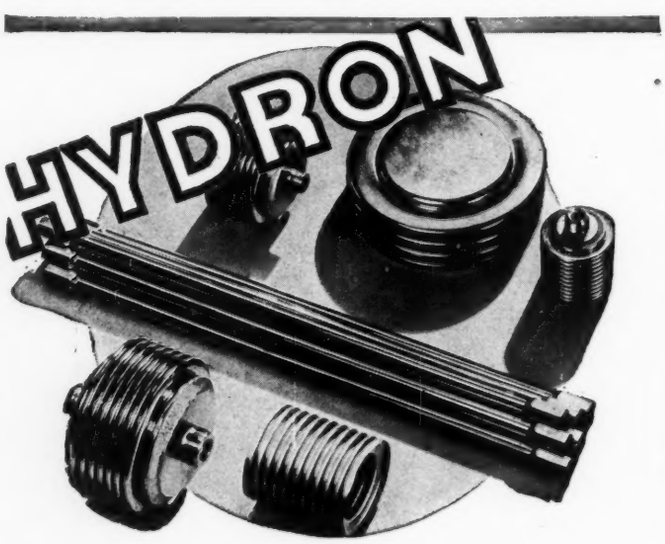

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Composite Stampings

(*Continued from Page* 115)

looked upon as generally the most suitable of all especially for comparatively small parts for they can be handled on an extremely high production basis on a conveyor-type continuous brazing furnace or even brazed in large quantities in batch-type furnaces.

Use of pins or rivets is also advantageous at times. A typical example of this method of joining stamped parts to make a composite is the hand-wheel built up of laminations and shown in *Fig.* 6. This handwheel consists of five laminations blanked out from ⅛-inch stock. The top piece carries a scale as shown, and the outside circumference of each lamination is notched to assure a ready grip.

This unit formerly was made from solid aluminum bar stock on an automatic screw machine. As redesigned for stamping, the five laminations are blanked out on small presses at high speed and at the same time holes are punched for the insertion of rivets to join the laminations.

As will be seen by referring to *Fig.* 6, changes in section are accomplished merely by varying the inside diameter of the hole punched in the laminations. To finish the handwheel after the laminations have been assembled by riveting, it is only necessary to thread internal diameter.

While this particular example did not succeed in reducing the cost of manufacture, the cost being the same by both methods, it did substitute steel sheets for aluminum bar stock, thus affording an important economy. At the same time, it released much automatic screw machine capacity for utilization in other critical work.

Stampings Produce Better Parts

It will be noted that all the examples of composite stampings described have the same dimensions at those points where the assembly must fit other parts as do those parts which they replace. In no instance has the composite stamping fulfilled the purpose of the part less satisfactorily than the original. In a number of instances it actually has been possible to produce a better part than previously.

It will be appreciated that the examples constitute only a small cross section of the work being done by the Ordnance Department to utilize the stamping capacity of the smaller manufacturers and to eliminate the needs for employing critical machine tools and materials.

Obviously it is not possible to disclose details of some of the most important examples of this method of redesign. However, it is possible to discuss two more examples of the type of work being done. *Fig.* 7 shows a fin locknut formerly made as a forging which was machined and threaded. Now it is a composite stamping. On an order for 2,000,000 units, this saving of critical machine tool time amounts to 100,000 machine hours. While it only requires 3 minutes to machine one fin locknut, the saving on this order alone means that 14 critical machine tools will be released for an entire year's work to help relieve any machining bottlenecks.

In *Fig.* 8 is shown a suspension guide fitting that formerly was made from three individually machined forgings. Now stamped steel parts assembled by copper brazing, the

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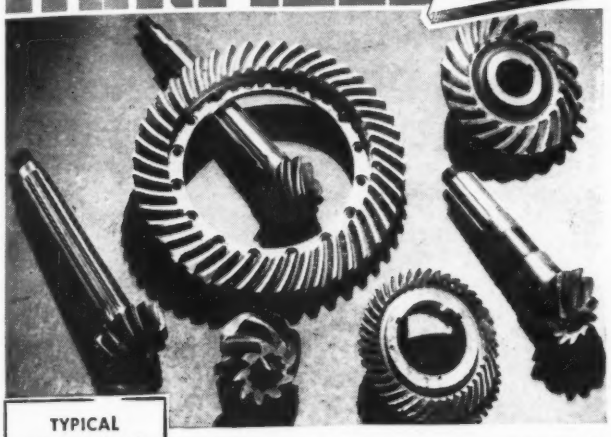

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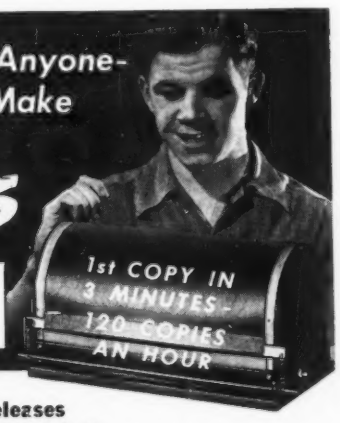

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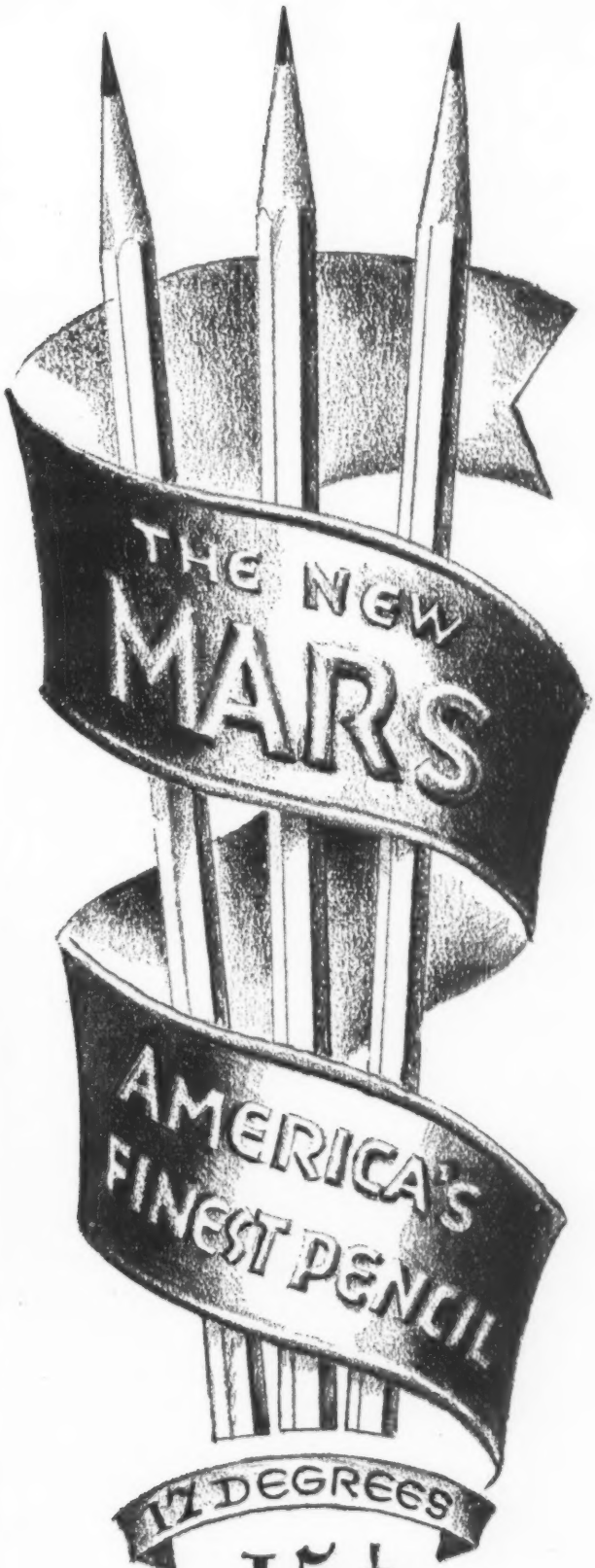

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To many readers the question will arise, "Why were not these parts and assemblies designed as stampings in the first place? Why was not this design work done long ago?" Here is the answer:

Because the function of our arsenals is to develop improved designs, it is not desirable to freeze designs to permit tooling up for mass production in peacetime. Full flexibility must be retained in manufacturing processes to permit utilization of improvements as fast as they are developed. Thus conditions imposed upon the designers at our arsenals and in other sections of the Ordnance department made it necessary to develop designs which lent themselves to production in small or comparatively small quantities. However, with the change to mass production of ordnance necessary to meet our war requirements, it now has become practical to redesign a good many parts.

A primary consideration in practically every case of redesigning a part from a forging or castings or from a part machined from a solid piece of metal is to avoid tying up production equipment that could be utilized more effectively on other war work. For instance, gun parts, shell bodies, airplane engine parts, aircraft landing gear parts and many other similar items must be made as forgings to obtain the desired combination of high strength, impact resistance, light weight, correct fragmentation or other characteristics. This means a tremendous demand upon all of our forging facilities.

Redesigning Releases Machine Tools

Because machine tools are needed to finish castings and forgings, and since many parts can be made most efficiently in automatic screw machines or in similar equipment, the machine tool capacity of the country is under a most severe burden. That is one of the primary reasons for changing many parts to stampings for, as has been shown, a good many comparatively complicated parts can be made as built up or composite stampings that require little or no machining due to the extreme accuracy to which the stamping and forming operations can be held.

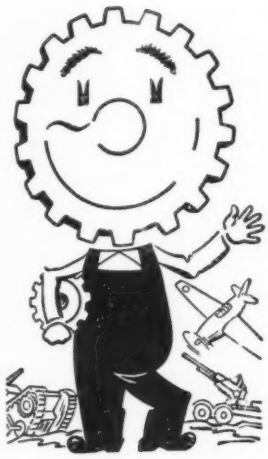
Ordnance department engineers are applying these production methods to complete assemblies with annual savings like these:

Steel	6,892,000	pounds
Brass	3,870,000	pounds
Copper	1,120,000	pounds
Zinc	100,000	pounds
Machine time	2,637,000	hours
Material savings	$750,000	

Applied to larger parts and larger assemblies, the results are expected to be even more startling. With thousands of acres of factory space and thousands of idle machines ready to lift the burden from overloaded machining, forging and casting equipment, this design activity promises to be one of the most important means of increasing our war output.

Much credit is due Col. H. M. Reedall, Capt. Graves Taylor and Lieut. H. C. Wolf of the Cleveland District Ordnance Office for their splendid cooperation in making the accompanying material available. Lieut. Wolf, in charge of this redesign work in the Cleveland district, was especially helpful.

From HERE to EVERYWHERE



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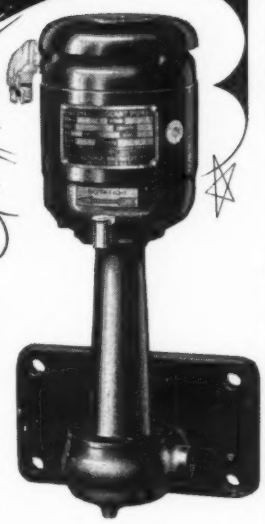

The mounting flange of this new Gusher Pump is comparatively large, so as to be interchangeable with larger size Gusher Pumps. Therefore, easily adaptable to changing types of machine production. Right or left discharge. 1/10 h.p. Capacity: through ½" pipe at 5 ft. head is 10 g.p.m. Specifications and data on request. Write!

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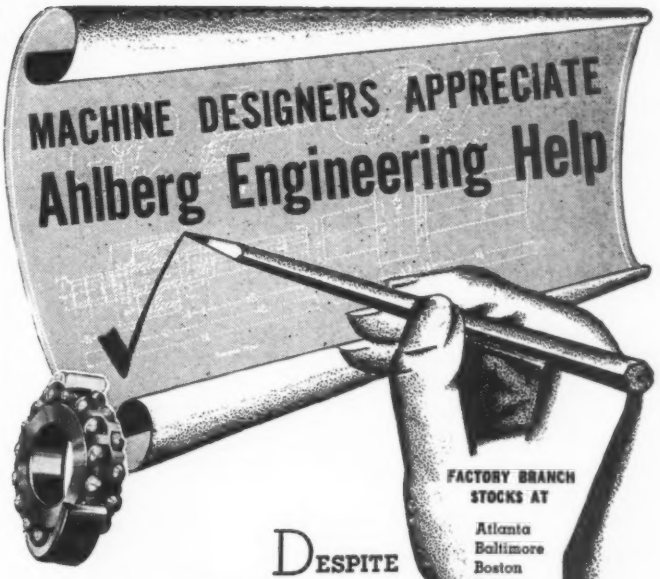

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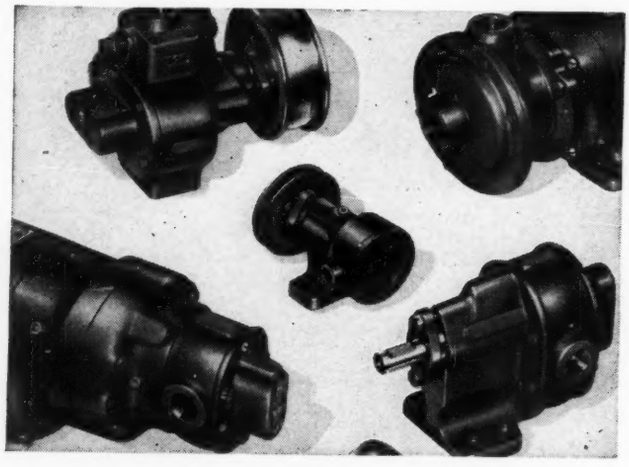

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BROWN & SHARPE PUMPS

Malleable Iron Fills Wartime Needs

(*Continued from Page* 98)

solidification, as is the case with gray iron, hence the design needs to be scrutinized for possible sources of shrinkage cracks or porous metal, especially as the white iron is extremely brittle, in contrast to the tough malleable into which it is converted in the anneal. Also due to the brittleness of the original white iron, permanent molds are unsuitable unless for extremely simple shapes, green sand molds being used in nearly all malleable production. Malleable castings may be so advantageously produced in green sand that when conversion is made from a cast steel part, redesign may accomplish the elimination of a dry sand core, as shown in *Fig.* 6, the base core becoming unnecessary. Because of the complete change of metal structure in the annealed malleable, original shrinkage stresses are entirely absent from the final product.

Wide Range of Sizes Possible

Sections as thin as 1/16-inch and as thick as two inches can be readily formed in malleable, though preferably not in the same casting. With sections substantially in excess of two inches special care is necessary to prevent formation of primary graphite in the original white iron casting. Size of individual castings ranges from a few ounces to several hundred pounds.

Where bronze castings have been replaced by malleable, as in the examples shown in *Fig.* 2, it has been found possible to retain essentially the same cutting speeds and feeds because of the excellent machinability of malleable. Machining accuracy is also high because of the high elastic modulus (see TABLE II) resulting in minimum distortion when the piece is held for machining in a chuck or fixture.

Through careful redesign it was possible to convert the part shown in *Fig.* 7 from aluminum to malleable with a weight increase of only 24 per cent in spite of the fact that malleable has more than two and a half times the density of aluminum. In this case conversion was dictated by the inability of the user to obtain aluminum due to low priority.

Castings Can Be Reshaped

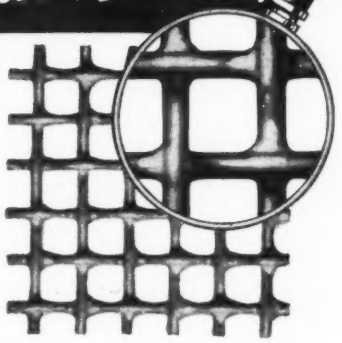
Malleable castings which may have distorted during the annealing process can be brought back to accurate size by using a hammer or press, employing dies if the quantity warrants. When this is done, machining allowances may be greatly reduced and sometimes much machining eliminated. Accuracy is also promoted by subjecting the casting to pressure for the purpose of providing a flat locating surface for the initial machining operation.

A striking example of how the ductility of malleable can be used to advantage in design is shown in *Fig.* 8. This ball and socket joint, formerly made in three parts including a top retaining cover, is now made in two parts with a series of fingers cast in the malleable base. Assembly of the joint consists in simply installing the ball

Look at the Node!!

. . . A Sure Sign of

THOROUGH COATING on "Buffalo" GALVANIZED WIRE CLOTH



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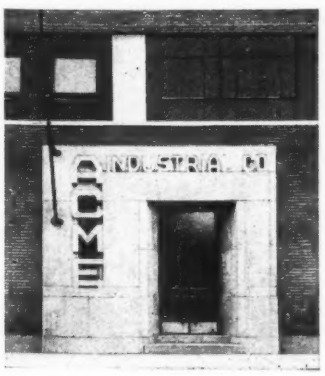

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A small third terminal shown in these fittings is used to operate a signaling device so that the pilot may know when the ground battery has been disconnected.

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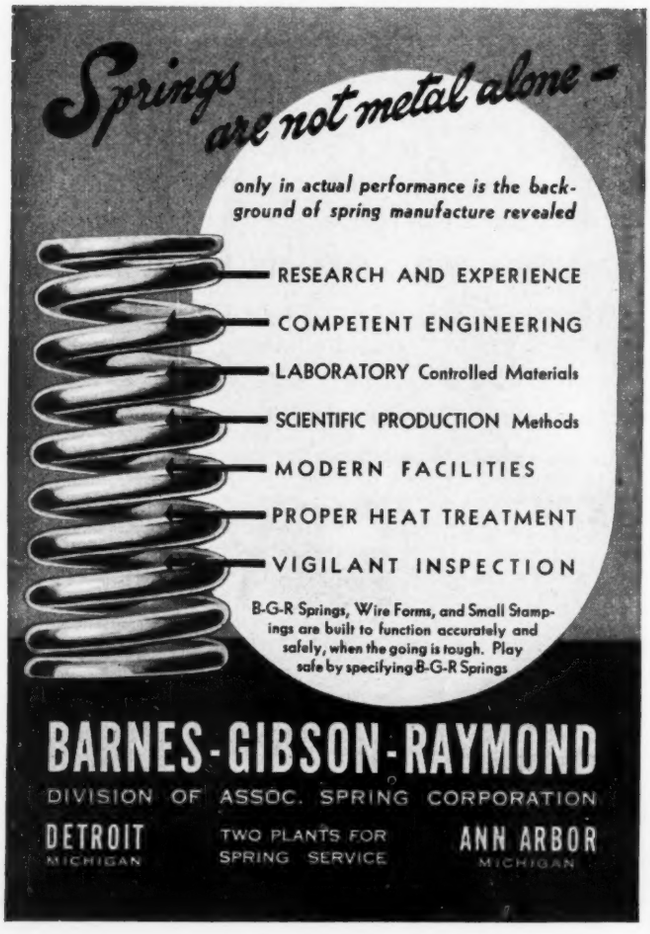
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element and bending the fingers in a press so as to retain the ball element.

For pipe fittings and valves, cupola malleable (TABLE I) is particularly well adapted. Although somewhat lower in strength and ductility, it has more fluidity and less shrinkage, also excellent machinability due to higher carbon content. The fluidity and shrinkage characteristics facilitate the production of castings which are tight under water and steam pressure.

Pearlitic malleable is finding increasing application in war machines for parts requiring high strength and abrasion resistance. In pearlitic malleable some of the carbon is combined as carbide, forming with the ferrite a pearlitic structure. This means that the matrix, instead of being carbon-free iron, is essentially carbon steel with a carbon content varying according to the properties desired. When combined carbon content is high enough, the material may be heat treated like steel, and production methods such as flame-hardening have been successfully employed. Tentative specifications have been issued for pearlitic malleable iron castings and are given in TABLE III.

TABLE III

Pearlitic Malleable Specifications[1]

Ordnance Dep't. Spec. AXS-623, Class	*A* and *C*	*B* and *D*	*E*
Tensile strength, min (psi)	75,000	65,000	60,000
Yield strength, min (psi)	60,000	50,000	43,000
Elong. min (per cent in 2 in.)	5	8	10
Brinell hardness number	241-187	207-163	179-140

[1]Tentative.

Alloy malleable irons in which no pearlite is present also have been developed for special purposes where high strength, wear resistance and other properties are needed. Alloying elements are of such a nature as to strengthen the ferrite and possibly also to permit some form of heat treatment. Of these, copper and molybdenum are used on a commercial scale.

Because the heat of fusion welding changes the structure and physical properties of malleable iron, castings so welded must be subsequently reannealed. With this restriction, gas and arc welding with special electrodes may then be used. If reannealing is impossible, bronze-welding is preferred, the method being similar to that used for gray cast iron. Prior to malleablizing, white iron castings can be resistance-welded, or may be gas-welded using electrodes of the same composition as the iron. After annealing, such welds are practically indistinguishable from the base metal.

Due to extensive mechanization, malleable foundries are well organized for the production of castings in quantity. Because the foundry engineers are familiar with their own production methods, they often can suggest small changes in design which may greatly accelerate production, cut weight and cost, and improve the accuracy and soundness of castings. It therefore behooves the designer to take advantage of the accumulated experience of the foundries and work in close cooperation with them.

MACHINE DESIGN acknowledges with appreciation the assistance of the following organizations in the preparation of this article: Belle City Malleable Iron Co. (*Fig.* 2); Lake City Malleable Co. (*Figs.* 6, 7 and 8); and the Malleable Founders Society (*Figs.* 3, 4 and 5).

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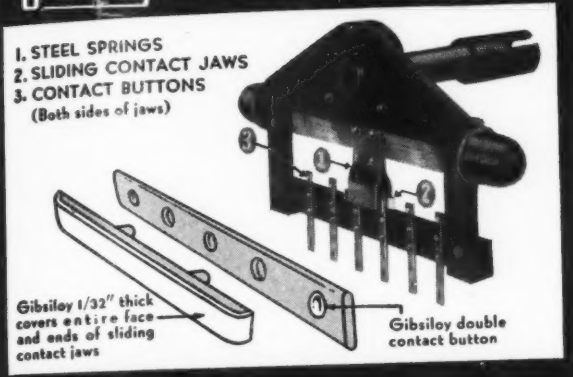
Gibsiloy SILVER-NICKEL CONTACTS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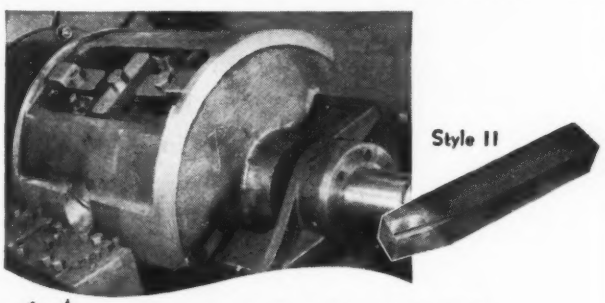

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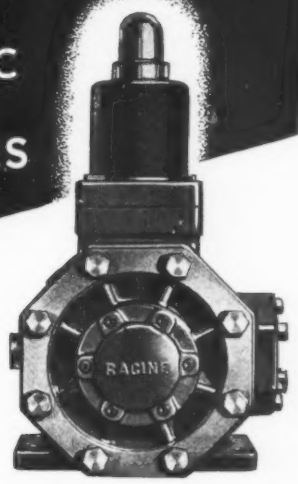

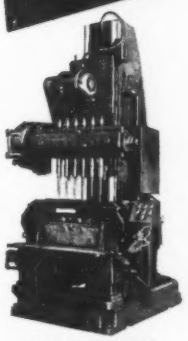
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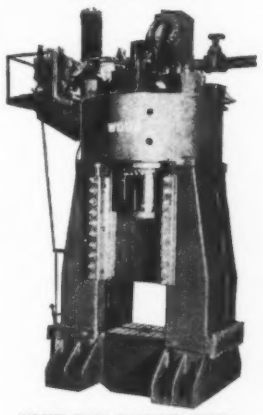
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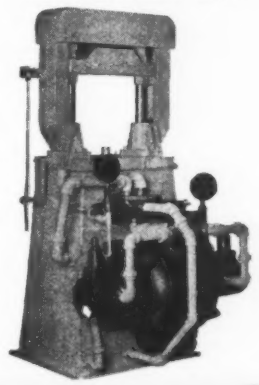
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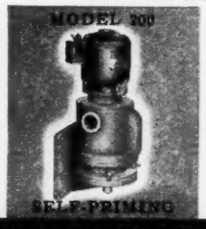

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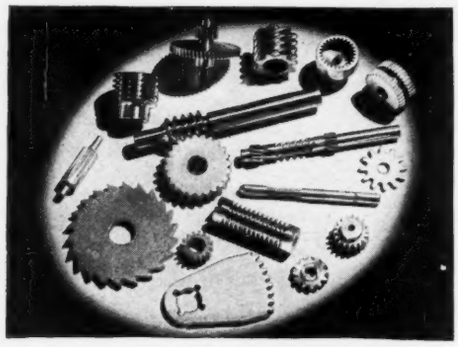

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Stress Raiser Effects

(*Concluded from Page* 107)

tempering temperatures but not below some finite, measurable value. A minimum value of notch ductility was reached for any of the steels investigated on tempering at a temperature of approximately 600 degrees Fahr., while tempering at 400 degrees Fahr. yielded somewhat higher values.

Until now, such a relation has not been observed in any static test; but a minimum of "toughness" is ascribed to steels tempered at temperatures close to 600 degrees Fahr. on the basis of notched bar impact tests. To investigate such a correlation, a few impact tests were carried out on heat treated bars of the SAE 3140 steel provided with two types of notches. The results of these tests, *Fig.* 11, show such a minimum for a tempering temperature of about 600 degrees Fahr. They also indicate that a sharp circular notch is more severe in impact tests than the more conventional wedge type notch with a fillet.

Static and Dynamic Energies Compared

The values of impact energy might be made comparable to the results of the static tests on notched bars by forming a composite value of the static characteristics which also has the dimensions of energy. This is the product of notch strength and notch ductility, which has been calculated for the SAE 3140 steel bars provided with 5 and 30 per cent notches, *Fig.* 12. In the range where 30 per cent notched bar yield reliable values, that is, for tempering temperatures above 800 degrees Fahr., the static, *Fig.* 12, and the dynamic energy, *Fig.* 11, depend upon the tempering temperature in much the same manner. The static conditions for low tempering temperatures have been represented only for the 5 per cent notched bars, which also show a similar trend but a slight displacement of the temperature of minimum energy to a lower temperature in comparison with the impact tests. Thus, this comparison shows that the much discussed results of notched bar impact tests are mainly determined by notching and only to a minor extent by the high speed of testing.

In order to check the effect of quenching temperature, a few specimens of the SAE 2340 steel were quenched from 1600 and 1750 degrees Fahr. The ultimate strength, elongation, and contraction in area of the unnotched bars were not visibly affected by the quenching temperature. This fact has been previously observed and cannot be explained as it is well known that the quenching temperature, which determines the austenitic grain size, affects the performance of a steel and its notch impact toughness to a considerable extent. This effect is apparent, however, in the case of the notch strength. The region of notch brittleness extends further in the direction of higher tempering temperatures when the hardening temperature is higher. Here again is an indication of the inability of the ordinary tensile properties to reveal the practical performance characteristics of a material, whereas these differences in materials are more readily distinguished by a notched bar tensile test.

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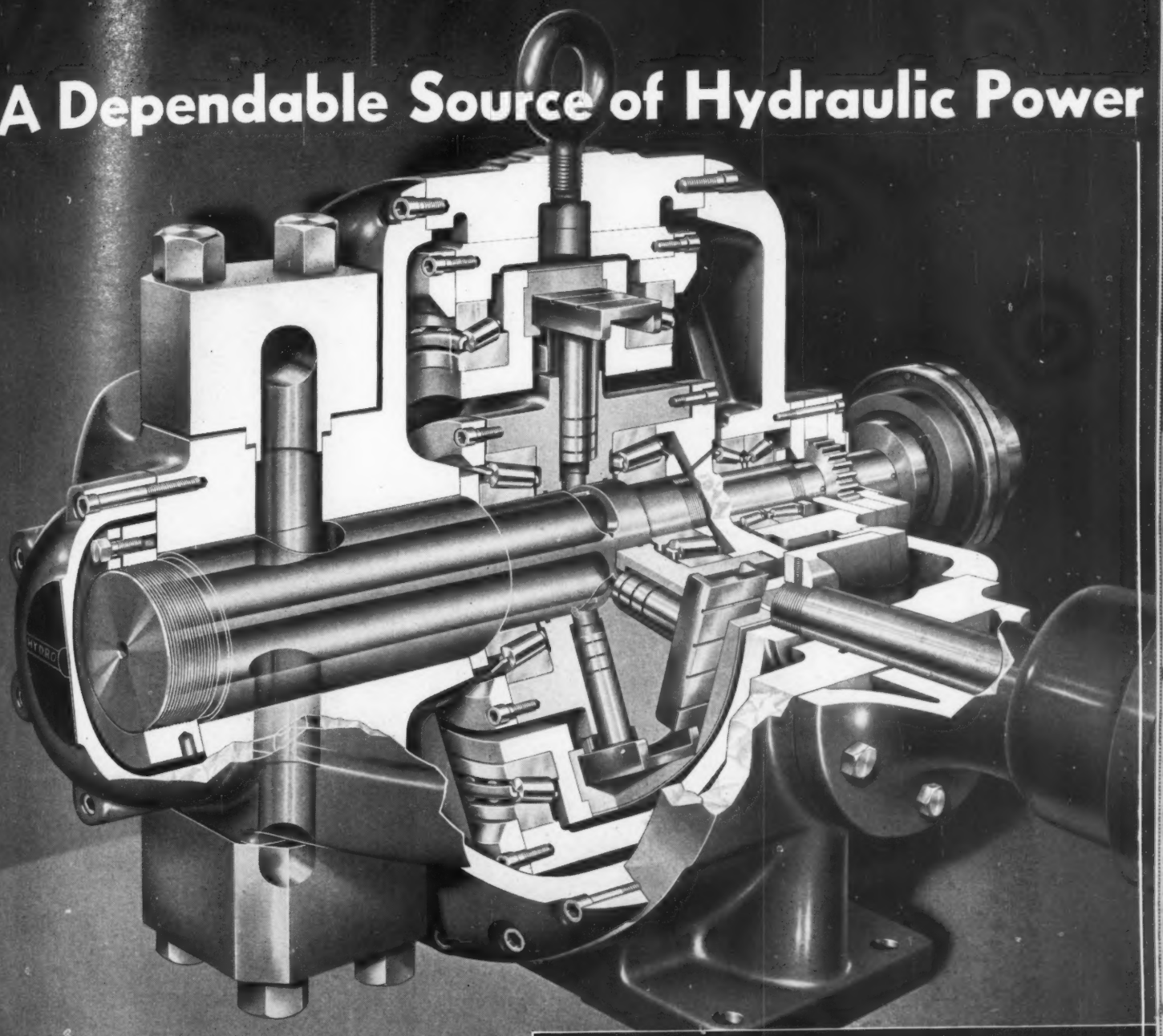

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THESE OUTSTANDING FEATURES:

1.—Tapered roller bearings maintain a positive mechanical separation between cylinder rotor and central valve spindle.

2.—Take-up adjustment of tapered bearings is provided to maintain initial pre-loading for life. This is accomplished from outside of pump, without dismantling.

Write for bulletin 411 giving full details

HYDRO-PCWER SYSTEMS, INC.
Division of The Hydraulic Press Manufacturing Company
Mount Gilead, Ohio, U. S. A.

hydro power

HYDRO·POWER
Radial Pumps Excel in Dependability and Efficient Operation

Hanna Cylinders

Air

Hydraulic

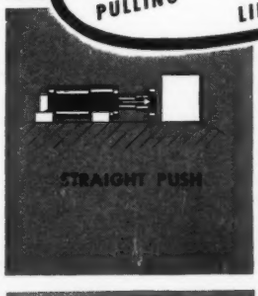
Why not use *Cylinder Power* on your machines?

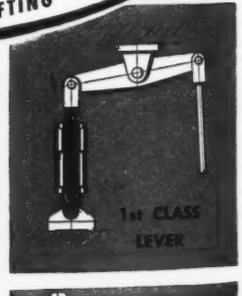
. . it is versatile, smooth, dependable, and easy to apply

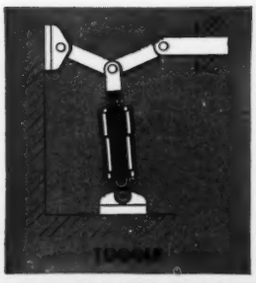
THIS Noble & Westbrook Shell Marking Machine illustrates how simply and effectively a Hanna Cylinder can be used to apply power — power that is dependable, easily controlled and economical.

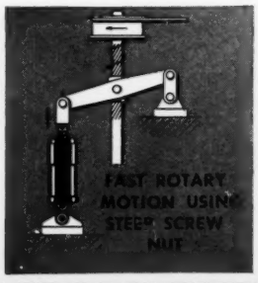
Throughout industry there are thousands of Hanna Cylinders at work on machines and equipment because they simplify and improve operation; they save time and labor; they help increase production. Wherever safe, reliable mechanical power is needed, they can deliver it—either direct, through a lever, toggle, or other mechanical arrangement. Study these illustrations of fundamental movements and you will probably find they suggest adaptations for the use of Hanna Cylinder Power, on your machines or in your plant.

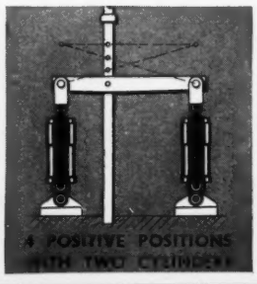
Write for catalog 230, or, if you wish, an Engineer will help you apply Hanna Cylinders to advantage.

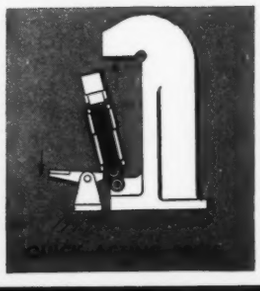


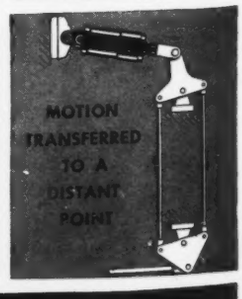












HANNA ENGINEERING WORKS
1765 ELSTON AVENUE • CHICAGO, ILLINOIS

Air and Hydraulic RIVETERS

Air and Hydraulic CYLINDERS

Air HOISTS

TITANIUM ALLOYS AVAILABLE

TAM
(F.C.T.) FERRO-CARBON-TITANIUM
FOR DEOXIDATION

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40% FERRO-TITANIUM
FOR STAINLESS STEEL

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There is no scarcity of TAM Titanium Alloys. Our expanded facilities enable us to fill orders for all requirements.

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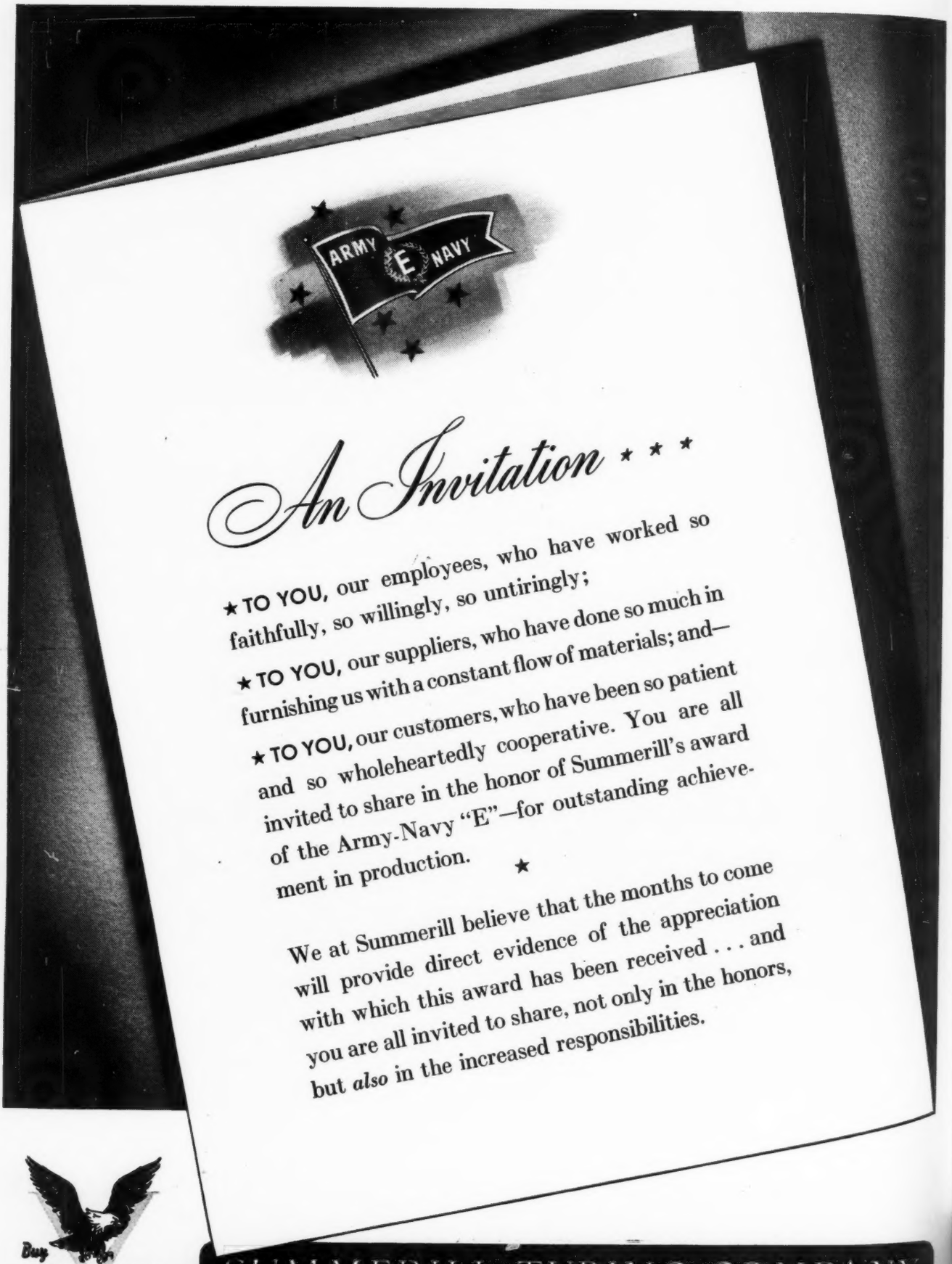
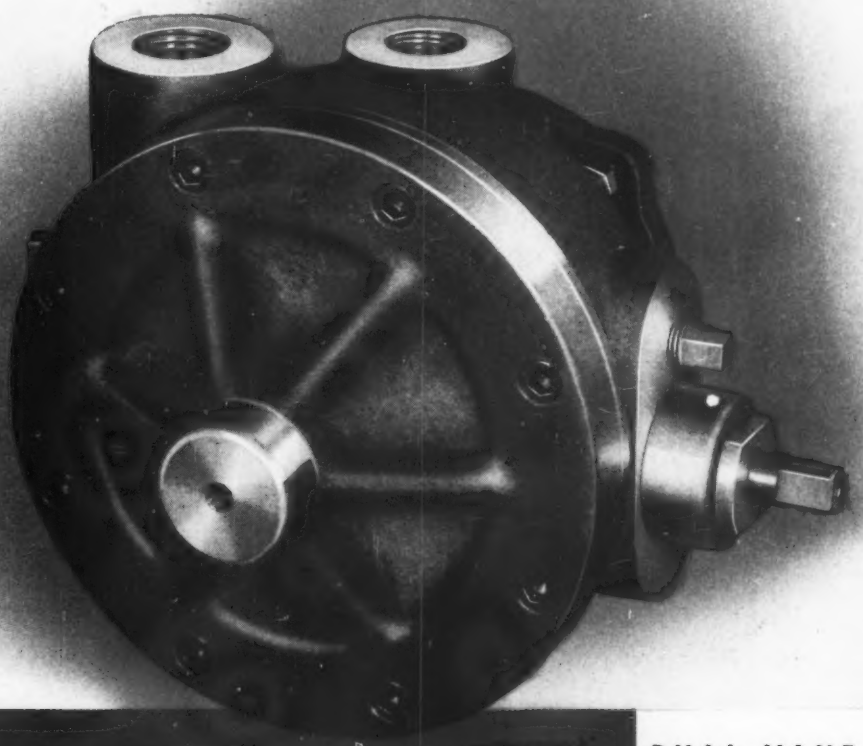
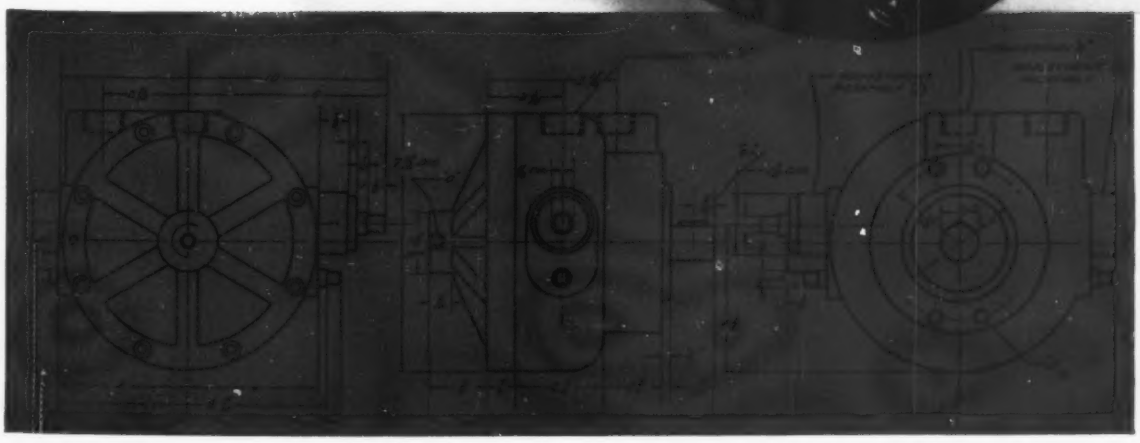

ARMY
E
NAVY
An Invitation ★ ★ ★
★ TO YOU, our employees, who have worked so faithfully, so willingly, so untiringly;
★ TO YOU, our suppliers, who have done so much in furnishing us with a constant flow of materials; and—
★ TO YOU, our customers, who have been so patient and so wholeheartedly cooperative. You are all invited to share in the honor of Summerill's award of the Army-Navy "E"—for outstanding achievement in production. ★
We at Summerill believe that the months to come will provide direct evidence of the appreciation with which this award has been received . . . and you are all invited to share, not only in the honors, but also in the increased responsibilities.
Buy WAR BONDS
SUMMERILL TUBING COMPANY
Seamless
BRIDGEPORT Montg. Co., PA.
Affiliated with EDGAR T. WARD'S SONS CO. and COLUMBIA STEEL & SHAFTING CO.

PROMPT SHIPMENT!

Hydraulic Infinitely Variable Delivery *DUAL-VANE* PUMPS



- High Operating Pressures (Up to 1000 lbs. per sq. in.)
- Infinitely Variable Delivery (0 to 4 gpm)
- Shock-Proof
- DUAL Balanced (Rotor balance; vane balance)
- Long Life
- Quiet Operation
- Simplicity of Design
- No Overheating
- Automatic Compensation for Wear



DUAL-VANE **infinitely variable delivery vane pump is compact, easily installed, easily serviced. The adjustment screw for varying delivery is at right.**

A	B	C	D	E	F	G	H
1-11½ PIPE TAP	¾-14 PIPE TAP	⅛-27 PIPE TAP	⅜-16 TAP ¾ DEEP	.245 +.000 −.001	1.0625 +.0000 −.0005 DIA.	⅜ x ¼ WOOD-RUFF KEY.	3.500 +.000 −.000 DIA.

I ADJUSTMENT ASSEMBLY 1. IS USED ON STANDARD LEFT HAND PUMPS—AS SHOWN.

II ADJUSTMENT ASSEMBLY 2. IS USED ON RIGHT HAND PUMPS IN WHICH THE DIRECTION OF ROTATION IS REVERSED.

III ADJUSTMENT ASSEMBLYS 1. AND 2. ARE USED FOR GREATER VOLUME CONTROL. REFER TO R.P.M. CHART.

R.P.M.	
1800	6 GALLONS PER MINUTE
1200	4 GALLONS PER MINUTE
900	3 GALLONS PER MINUTE

You can get this standard pump now. The type of mounting should permit it to be used as replacement without changing mounting designs. DUAL-VANE construction permits it to do work that conventional pumps cannot do.

Our engineering and manufacturing departments are particularly interested in helping you solve the more *uncommon* type of hydraulic problem.

HYDRA-MOTIVE

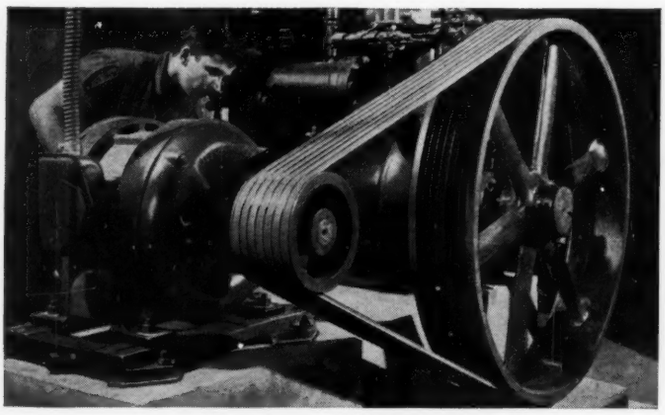
DIVISION

Manufacturers of DUAL-VANE fluid motors and pumps for hydraulic (oil) operation

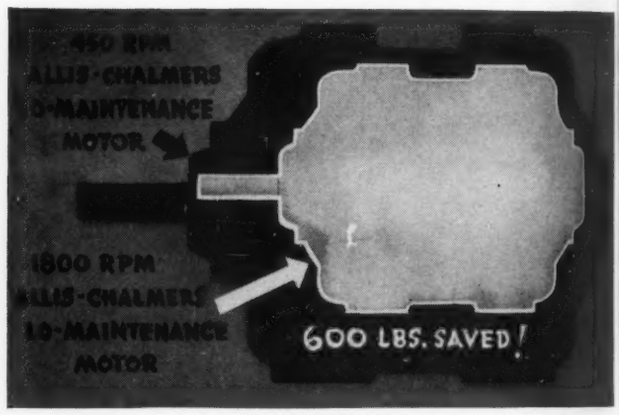
[illegible] E. MILWAUKEE AVENUE, DETROIT, MICHIGAN

It's Time to Look at Motor

➔*You Can Save with High-Speed Instead of*

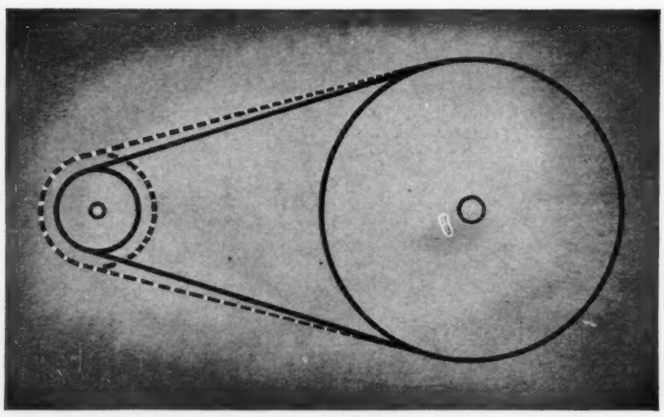


1. In most applications, an 1800 rpm motor with Texrope Drive will ably do the job of a lower-speed, direct-connected motor . . . *and* give you *exactly* the speed you want — *at lower cost!*



2. When you buy an 1800 rpm instead of 450 rpm 15 hp squirrel-cage motor, for example, 600 lb of critical materials are saved. And *you* save well over $200—with the drive figured in! This saving is typical.

➔*You Can Save with Single-Speed Instead of*



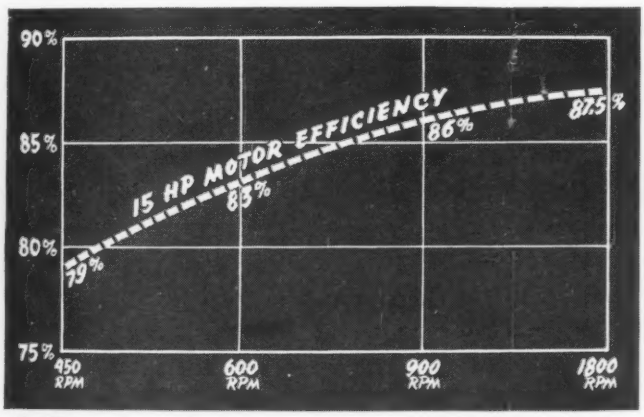
1. Infrequently needed speed changes can be had by changing from one size motor sheave to another. By juggling *complete* drives, speeds can be changed over the full range — from 1:1 to 7:1.

2. With the Allis-Chalmers Vari-Pitch Sheave, you can increase or decrease speed by adjusting sheave diameter, as above. Within limits, an unbroken series of speeds can be obtained.

Take a Fresh Buying!

WAR FORCES HIGHER EFFICIENCIES...

Low-Speed Motors...



3. Note that efficiency rises from 79% for a 450 rpm motor to 87.5% for a 1800 rpm motor. Comparing power consumption, the 1800 rpm motor saves you over 30 kw/24 hr. day.

Multi-Speed Motors...

3. Allis-Chalmers Vari-Pitch Speed Changer gives you infinite changes at the turn of a wheel — within 3.75 to 1. It's the most compact, flexible variable-speed transmission available.

It was good business in peacetime to use — as widely as possible — high-speed motors with Allis-Chalmers Texrope Drives...and single-speed motors with Allis-Chalmers Vari-Pitch Sheaves and Speed-Changers. And it's clearer every day that those material and money-saving practices are *vital* practices in time of war!

TODAY the whole picture of buying and applying motors has changed. Note at the left how much you can save for your country *and yourself* with high and single-speed motors made flexible by Texrope Drives.

As America's only builder of both electric motors and V-belt drives,* Allis-Chalmers has long advocated the proper combining of motor and V-belt drive.

And today you benefit from Allis-Chalmers' vast, pioneering experience in this field when you ask for and get the *right* combination of Lo-Maintenance Motor and Texrope Drive! Call your nearby district office. Or write ALLIS-CHALMERS MFG. CO. MILWAUKEE, WISCONSIN.

A 1560

*Allis-Chalmers *originated* the Multiple V-Belt Drive and Vari-Pitch Sheaves.

ALLIS-CHALMERS A-C MILWAUKEE

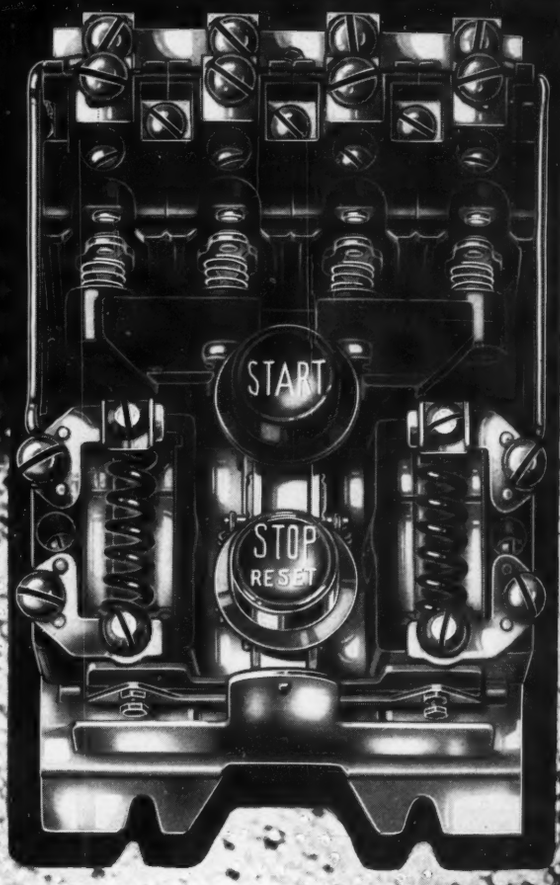
WE WORK FOR VICTORY WE PLAN FOR PEACE

For Motor Control and Overload Protection

Re-settable Thermal Switches

ARROW H&H

Manually operated



MANUAL STARTERS

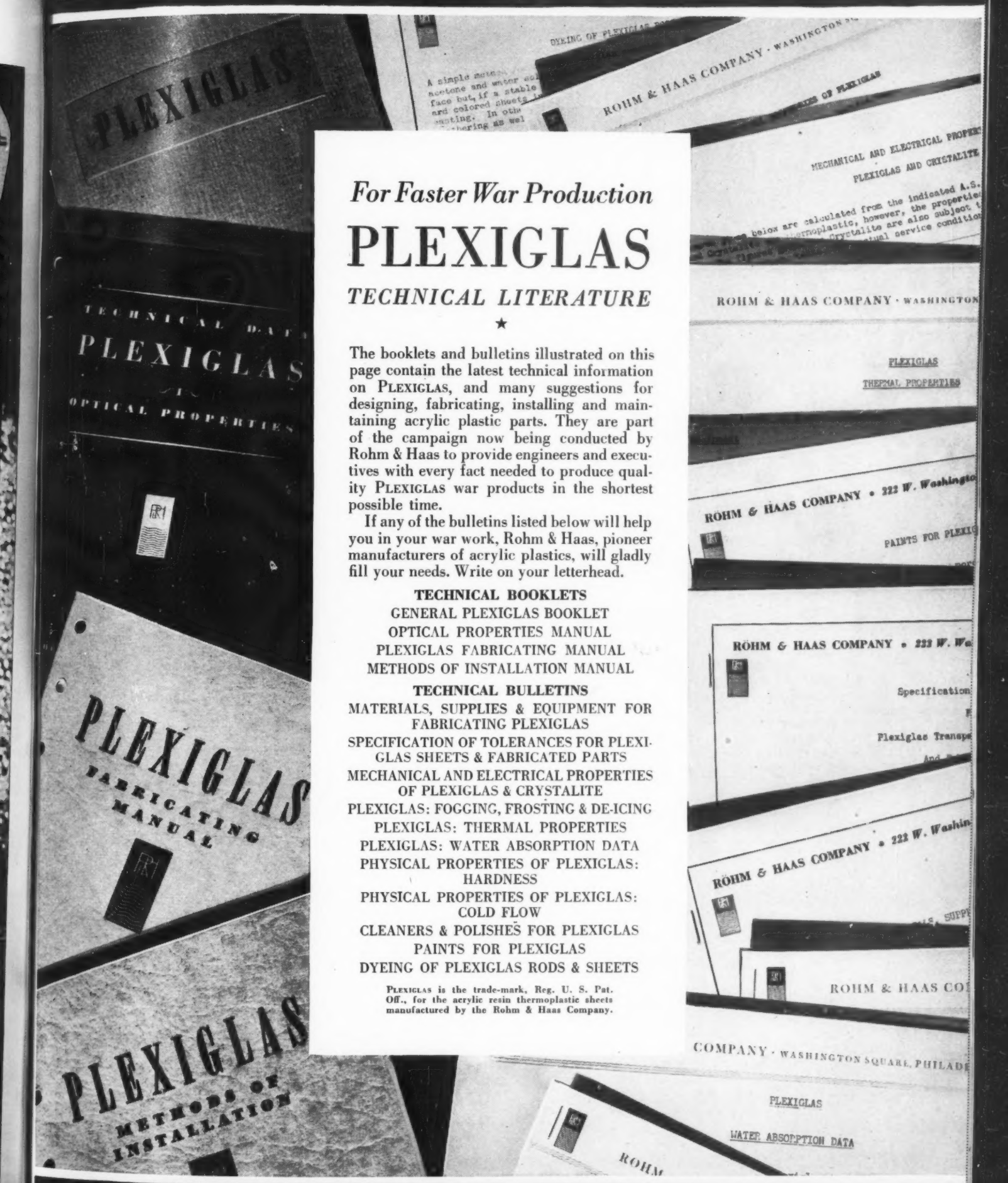
Give your war-driven machines the right "START"—keep them under safe CONTROL — hold them to emergency peaks without risk of motor overloads! Let ARROW-H & H Switches carry *this* load of responsibility for your production.

Thermal overload protection for motors up to 7½ H. P., 440-550 Volts, sizes "0" and "1". Available in *reversing* and *two-speed* types, mechanically interlocked. Handy front-operating manual control, with "Start" — "Stop-Reset" Push Buttons.

Across-the-Line Type ("RT"); *straight-line linkage* mechanism, — no wipe on contacts, minimum of mechanical wear. Contacts silver to silver butt type; movable contacts full-floating, self-adjusting. NEMA Type 1 housing, also dust and weather-proof. Refer to Catalog 9-M for listings or write our Free Engineering Service for control layouts.

INDUSTRIAL CONTROL DIVISION

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.



For Faster War Production

PLEXIGLAS

TECHNICAL LITERATURE

★

The booklets and bulletins illustrated on this page contain the latest technical information on PLEXIGLAS, and many suggestions for designing, fabricating, installing and maintaining acrylic plastic parts. They are part of the campaign now being conducted by Rohm & Haas to provide engineers and executives with every fact needed to produce quality PLEXIGLAS war products in the shortest possible time.

If any of the bulletins listed below will help you in your war work, Rohm & Haas, pioneer manufacturers of acrylic plastics, will gladly fill your needs. Write on your letterhead.

TECHNICAL BOOKLETS

GENERAL PLEXIGLAS BOOKLET
OPTICAL PROPERTIES MANUAL
PLEXIGLAS FABRICATING MANUAL
METHODS OF INSTALLATION MANUAL

TECHNICAL BULLETINS

MATERIALS, SUPPLIES & EQUIPMENT FOR FABRICATING PLEXIGLAS
SPECIFICATION OF TOLERANCES FOR PLEXIGLAS SHEETS & FABRICATED PARTS
MECHANICAL AND ELECTRICAL PROPERTIES OF PLEXIGLAS & CRYSTALITE
PLEXIGLAS: FOGGING, FROSTING & DE-ICING
PLEXIGLAS: THERMAL PROPERTIES
PLEXIGLAS: WATER ABSORPTION DATA
PHYSICAL PROPERTIES OF PLEXIGLAS: HARDNESS
PHYSICAL PROPERTIES OF PLEXIGLAS: COLD FLOW
CLEANERS & POLISHES FOR PLEXIGLAS
PAINTS FOR PLEXIGLAS
DYEING OF PLEXIGLAS RODS & SHEETS

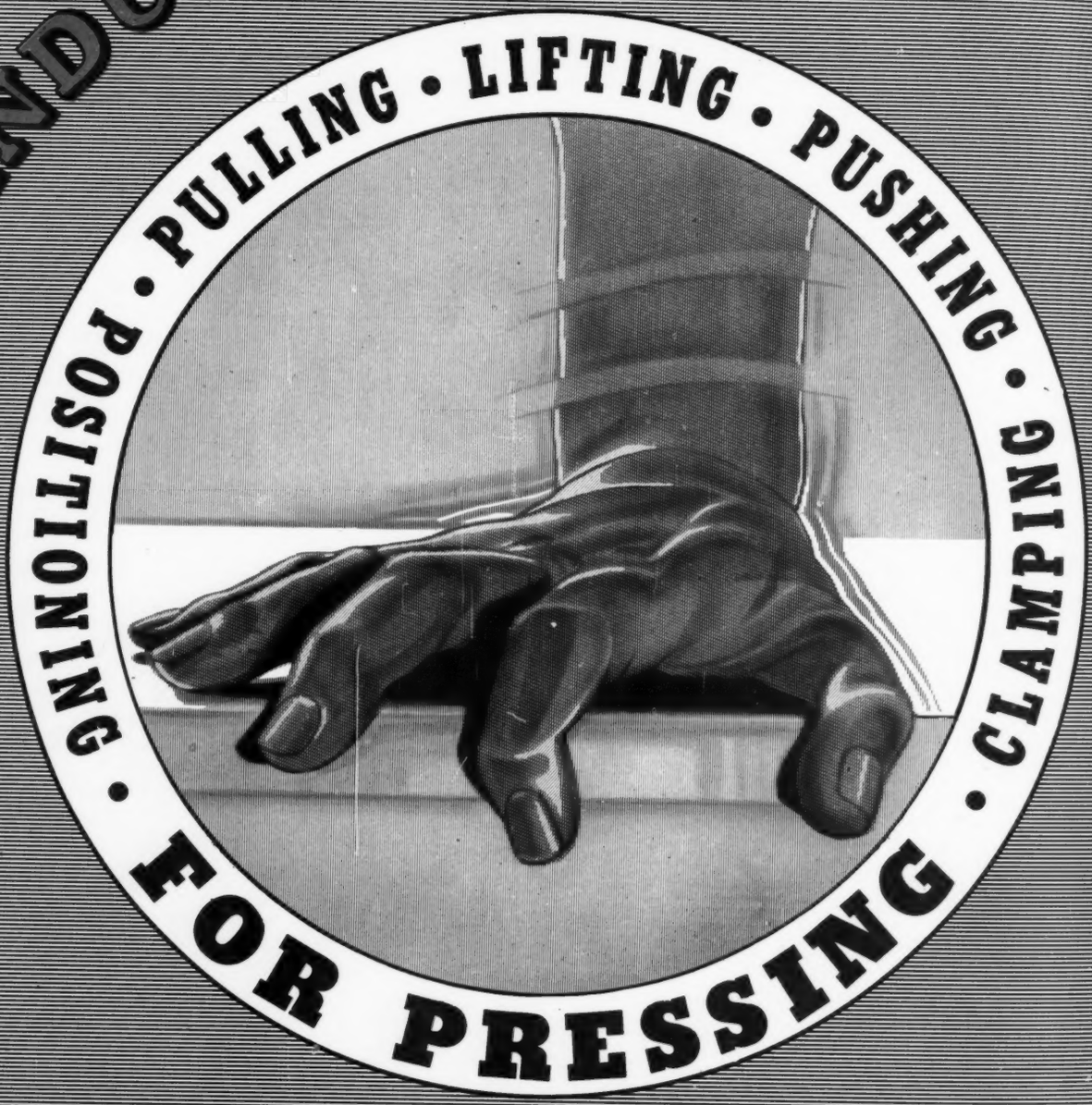
PLEXIGLAS is the trade-mark, Reg. U. S. Pat. Off., for the acrylic resin thermoplastic sheets manufactured by the Rohm & Haas Company.

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA, PA.

Manufacturers of Leather and Textile Specialties and Finishes . . Enzymes . . Crystal-Clear Acrylic Plastics . . Synthetic Insecticides . . Fungicides . . and other Industrial Chemicals

INDUSTRY'S NEW RIGHT

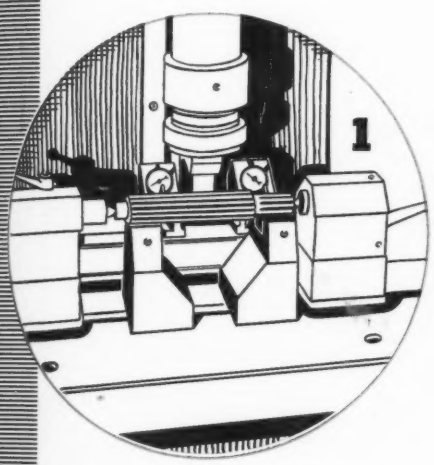


WHEREVER YOU NEED

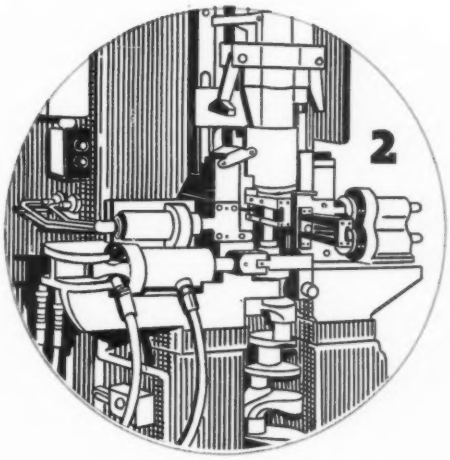
POWER
SPEED
CONTROL

H HAND

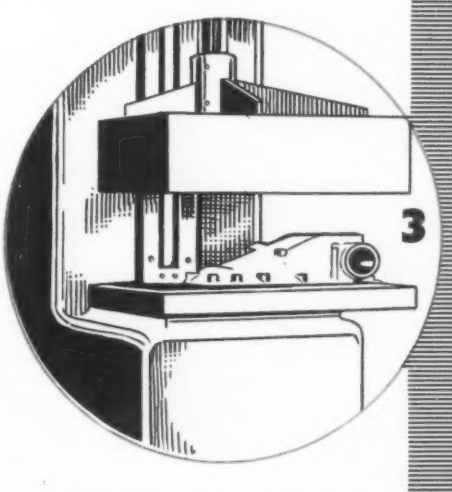
You get an idea of what we're driving at in talking about the wide flexibility of HydrOILics when you view some of the amazing variety of pressing jobs it is handling. Of course, HydrOILics is doing all the every-day, run-of-mine jobs production men are familiar with — doing them with greater accuracy of power, speed and control. But what we especially want to call to your attention is how HydrOILics gives you an inside track in solving new production problems and improving on older methods. HydrOILics is exceptionally flexible because it uses oil to transmit power and motion, and this fluid transmission makes it readily and accurately adaptable to an endless variety of operations. It is this angle of HydrOILics that makes it Industry's new right hand.



Another example is a HydrOILic press with special straightening centers and indicator gauges calibrated in thousandths of an inch (Fig. 1). It quickly straightens minute irregularities in hardened steel transmission shafts, checking the shafts accurately right along with the straightening operation.



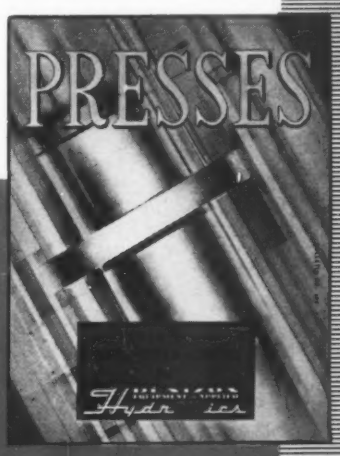
A HydrOILic press that assembles keys and timing gears on automotive crankshafts is one example (Fig. 2). A crankshaft is locked in position, keys are fed into the press through special magazines, four special cylinders assemble the two keys, and the timing gear is pressed into place by the ram. If a gear or any one of the keys fails to fit exactly, all of the pieces are automatically rejected.



A third press, too intricate to describe here in much detail, hydrostatically tests the pressure ports of cylinder heads, automatically rejecting any that aren't up to scratch. A shield on the press ram completely encloses the castings during the tests, safeguarding the operator in case of a fracture.

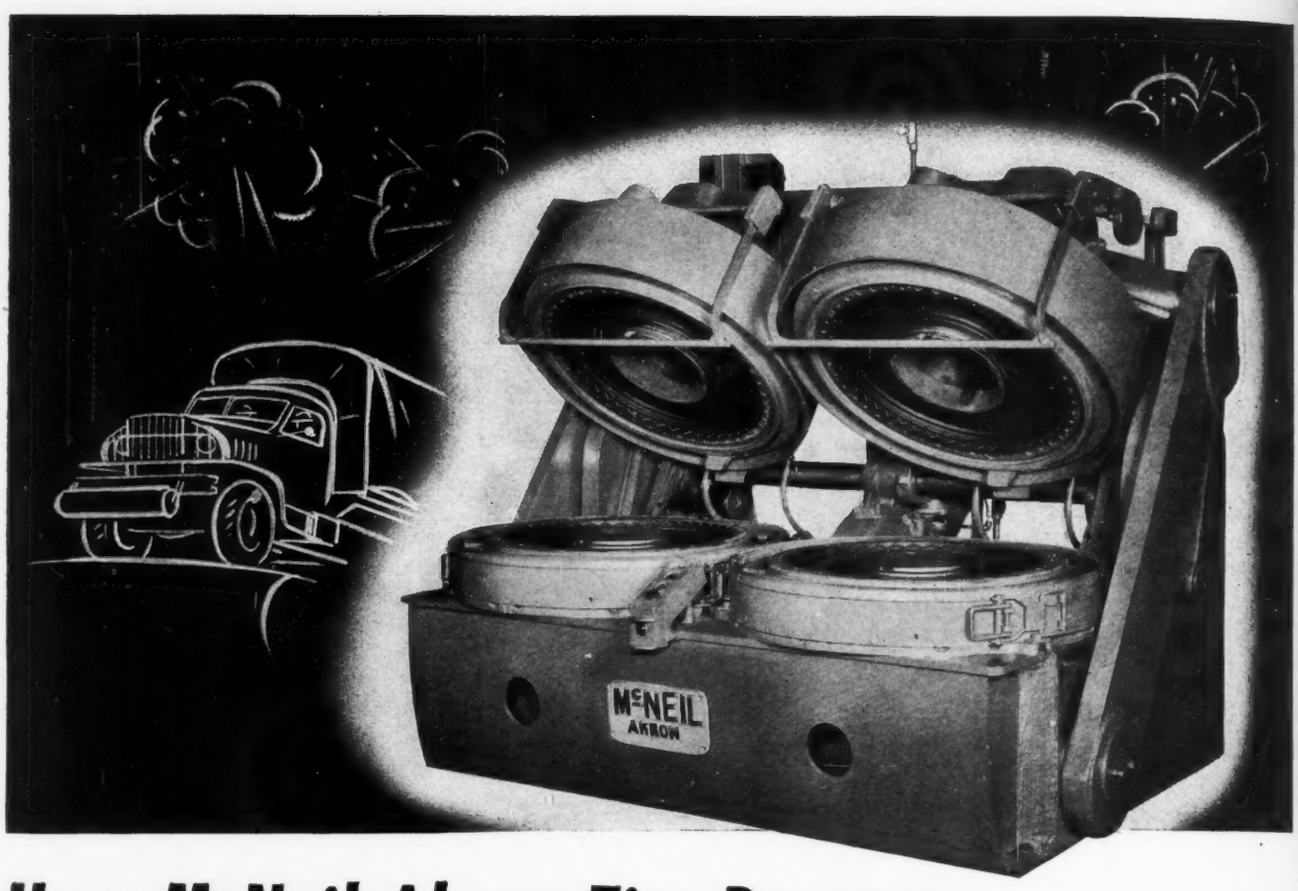
But why not let us get specific about how HydrOILics can improve your own production? Write us for any information you desire, or call your Denison representative. And ask for your copy of the new catalog on Denison's full line of versatile, standard HydrOILic Presses. Ranging up to 100 tons in capacity, they handle dozens of production jobs with more efficient power, speed and control. And for your convenience, we've included 12 full pages of frequently used engineering tables, indexed for quick reference. Your engineering department will want this data. Write today!

THE DENISON ENGINEERING COMPANY
1156 DUBLIN ROAD, COLUMBUS, OHIO



Check

DENISON
EQUIPMENT *in* APPLIED
HydrOILics



How McNeil Akron Tire Presses use Ohio PRECISION Gears TO HELP "KEEP 'EM ROLLING"

The bewildering rubber shortage ballyhoo has wholly obscured the fact that tire plants are continuing their day-in-day-out production at greater speeds than ever before. Jeeps, army trucks and guns have an insatiable appetite for tires. So, many of the leading tire plants are depending on speedy McNEIL AKRON curing presses to help them meet their high daily quotas.

On the McNeil Akron press, a special Ohio Gear worm and worm wheel transmits power from the high torque motor to identical crank gears located at the ends of the shaft shown just back of the molds. These crank gears provide the motion which opens and closes the huge molds, automatically stripping the tires from the molds in the opening operation.

"We have been using OHIO GEARS exclusively," say officials of the McNeil Machine & Engineering Co., "because they have proved so satisfactory and because OHIO GEAR engineers have cooperated so fully with our own engineering department in working out the types of transmission needed for our equipment. We've found OHIO GEAR CO. highly satisfactory too, from a price and delivery standpoint."

Transmitting power in tire curing operations is another way in which OHIO GEAR engineering skill and manufacturing experience is contributing to industry's huge war effort.

THE OHIO GEAR CO.
1338 E. 79th Street • Cleveland, Ohio

★ ★ ★

*NEW YORK CITY, N. Y.
Patron Transmission Co.
154-156 Grand Street

NEW ENGLAND
George G. Pragst
332 Main St., Pawtucket, R. I.

*LOS ANGELES, CALIF.
J. W. Minder Chain & Gear Co.
927 Santa Fe Avenue

GRAND RAPIDS, MICH.
W. H. Slaughter
1924 Madison Ave., S. E.

*PITTSBURGH, PA.
Standard Machinists Supply Co.
South 2nd and McKean Street

DETROIT, MICH.
George P. Coulter
322 Curtiss Building

**Stocks carried.*

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Industrial Supply Co.
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F. E. Allen, 2665 Main St.

*KANSAS CITY, MO.
Kansas City Rubber & Belting Co.
712 Delaware Street

*SAN FRANCISCO, CALIF.
Adam-Hill Co.
244-246 Ninth St.

LOUISVILLE, KY.
Alfred Halliday, 330 Starks Bldg.

*INDIANAPOLIS, IND.
A. R. Young
715 Fort Wayne Avenue

ST. LOUIS, MO.
St. Louis Tool Co.
2319 N. Ninth Street

★ ★ ★

OHIO GEARS

Bring your Spring Problems to us!

Here's expert help to speed up your war production

WAR is Hell—and no one knows it better than the design engineer called upon to furnish springs for modern fighting equipment.

Springs for such application must withstand stresses unheard of in peacetime. They must often fit niggardly limits of space and weight. They must function efficiently under incredible extremes of temperature, weather and atmosphere. And they must stand up in service on battlefields in every corner of the globe—on burning deserts, in steamy jungles, in the frozen spaces of the stratosphere, amid the salty spray of every sea.

These requirements impose problems the designer has seldom faced before. His job is made more difficult by the fact that shortages of critical alloying elements constantly tend to befuddle his choice of the proper steel for the purpose. That is why the help of our spring specialists can be so valuable right now.

These men, as recognized authorities in spring engineering, have collaborated in providing correct springs for every type of equipment America produces for war. Springs for tank and airplane cannon, for anti-aircraft guns, for projectiles, bombs, land mines, torpedoes, for precision instruments of all kinds. Their competent assistance is placed freely at your disposal. We welcome the opportunity to work with you.

AMERICAN STEEL & WIRE COMPANY

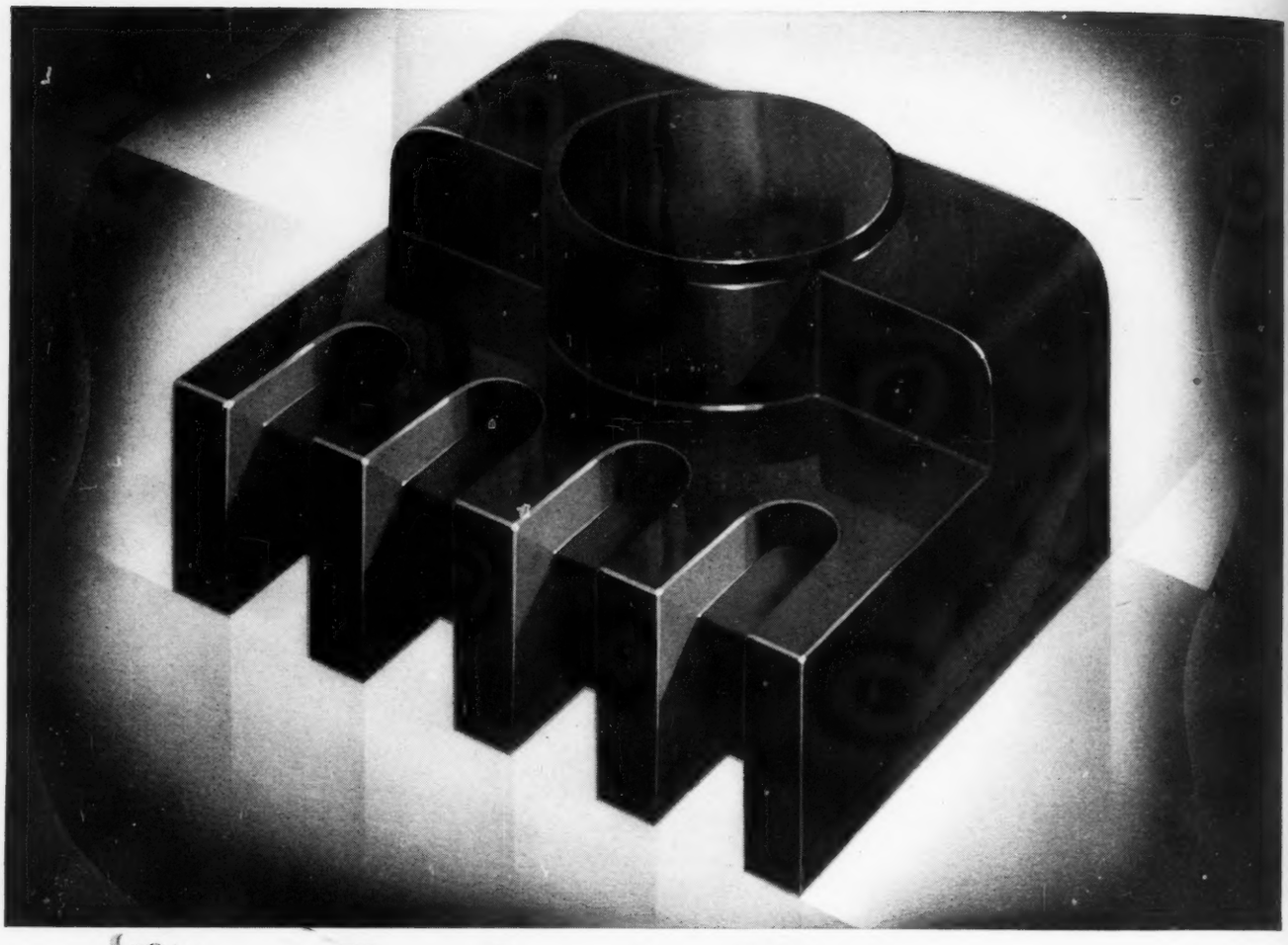
Cleveland, Chicago and New York

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Export Company, New York

FIRST IN WAR...
FIRST IN PEACE...
U·S·S American Quality Springs

USS

UNITED STATES STEEL



How they simplified the "Life of Inspector Riley"

ONCE he was known as *rejector* Riley and that meant trouble--trouble for him—shut-down on the assembly line—and slow-down of the company's war effort.

But that was before Richardson Plasticians and the contractor's engineers started working together—before the part was made of Molded INSUROK.

In hundreds of ways, Richardson Plasticians have helped scores of manufacturers win acceptance and enthusiastic approval for their war products and parts. And INSUROK Precision Plastics have been the means of successfully meeting many a tough specification—of speeding up production that might otherwise be delayed.

If you have a problem which molded or laminated plastics might solve—or a plastics fabrication problem on which years of experience might be beneficial, write us.

The Richardson Company, Melrose Park, Illinois; Lockland, Ohio; New Brunswick, New Jersey; Indianapolis, Indiana. Sales Offices: 75 West Street, New York City; G. M. Building, Detroit, Michigan.

INSUROK *and the experience of Richardson Plasticians are helping war products producers by:*

1. Increasing output per machine-hour.
2. Shortening time from blueprint to production.
3. Facilitating sub-contracting.
4. Saving other critical materials for other important jobs.
5. Providing greater latitude for designers.
6. Doing things that "can't be done."
7. Aiding in improved machine and product performance.

INSUROK

MADE AND SOLD ONLY BY THE RICHARDSON COMPANY

HOW YOUR MACHINES CAN GIVE

1. MORE SKILLED MAN-HOURS

2. GREATER PLANT OUTPUT

with Easy-to-Apply G-E TIMERS

FOR GREATER MACHINE OUTPUT

G-E timers relieve skilled operators of nonproductive clock-watching work. ● Make timing operations accurate and independent of operators' experience. ● Control speed of machines and conveyors to suit the skill of operators. ● Warm up furnaces and similar equipment before work, so operators can put in a full day.

FOR MORE SKILLED MAN-HOURS

G-E timers eliminate waste and spoilage caused by under- and over-timing. ● Keep motors on the line in spite of momentary power interruptions. ● Complete operations (such as heating and washing processes) after workers leave. ● Co-ordinate the operation of separate machines for continuous production.

TSA-10 INTERVAL TIMER

Telechron motor timed. Timing range from 0–5 seconds to 0–6 hours. Stepless variations of interval from 0% to 100% of maximum time. Voltage—115; 230 v. Frequency—25, 50, or 60 cycles. Circuit arrangement—single-pole, single-throw. Contact rating—1 amp at either 115 or 230 volts. Timer can be set externally or internally. Repeating operation requires another contact at zero. (Bulletin GEA-1771.)

TSA-14 CYCLIC TIMER

Telechron motor timed. Timing range from 10 seconds (total cycle) to 1 hour (total cycle). Continuously repeats a cycle of opening and closing contacts. Stepless operation from 1% to 99% of maximum time. Voltage—115 or 230 v. Frequency—25, 50, or 60 cycles. Circuit arrangement—single-pole, double-throw. Contact rating—10 amp at either 115 or 230 volts. Timer set internally. Repeats ON and OFF at selected time continuously. (Bulletin GEA-2963.)

VACUUM-TUBE TIMER CR7504

Capacitor-timed, non-repeat-type timer. Six types give over-all timing range of 0.045 second to 120 seconds. Stepless operation from 5% to 100% of maximum time. Voltage—115, 230. Frequency—25 or 50/60 cycles; also for d-c operation. Circuit arrangement—single-pole, double-throw. Contact rating—1 amp at 115 v; 0.5 amp at 230 v. External time set. Requires two timers independently adjustable for repeating operation. (Bulletin GEA-2902.)

CR2820 TIME-DELAY RELAY

Telechron motor timed, interval type. Timing range from 4 seconds to 2 hours. Adjustment range from 10% to 100% of maximum time; steps approximate 5% of maximum time. Maximum voltage—600. Frequency—25, 50, or 60 cycles; also available for d-c operation. Circuit arrangement—single-pole, double-throw. Contact rating—15 amp at either 115 v or 230 v. Internal time setting. Requires two timers (independently adjustable) for repeating operation. (Bulletin GEA-2616.)

T-44 GENERAL-PURPOSE TIME SWITCH

Telechron motor timed. Opens and closes circuit at predetermined times. Astronomic dial for ON–OFF operation at dusk and dawn; skips ON operation for selected days. Minimum time interval—45 minutes. Maximum voltage—230. Frequency—25, 50, or 60 cycles. Circuit arrangement—single-pole, single-throw; single-pole, double-throw; double-pole, single throw; double-pole, double-throw. Contact rating—35 amp at either 115 v or 230 v. (Bulletin GEA-1427.)

The Navy "E", for Excellence, has been awarded to 92,780 General Electric employees in six plants manufacturing naval equipment.

IS YOURS A SPECIAL PROBLEM?

Whenever you would like assistance with a special timing problem, the nearest G-E office will be glad to help.

SEND FOR FURTHER INFORMATION

General Electric, Sec. D676-10
Schenectady, N. Y.

I'd like more information about your timers. P send me the bulletins checked:

☐ *GEA-1771* ☐ *GEA-2902* ☐ *GEA-*
☐ *GEA-2963* ☐ *GES-2616*

NAME.....

COMPANY.....

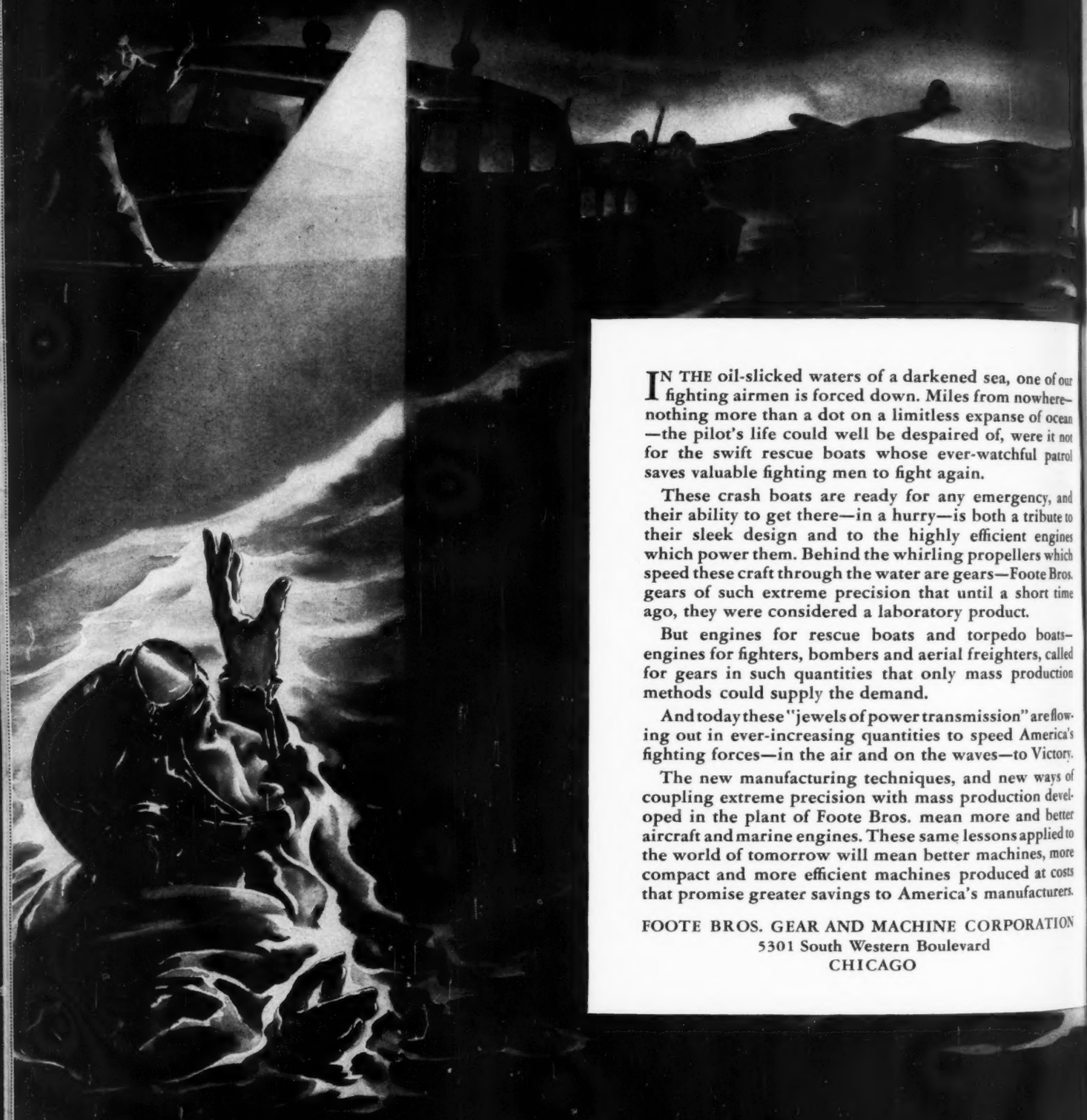
ADDRESS.....

CITY.....*STATE*.....

676-10-560

GENERAL ELECTRIC

He'll live!...to fight again



IN THE oil-slicked waters of a darkened sea, one of our fighting airmen is forced down. Miles from nowhere—nothing more than a dot on a limitless expanse of ocean—the pilot's life could well be despaired of, were it not for the swift rescue boats whose ever-watchful patrol saves valuable fighting men to fight again.

These crash boats are ready for any emergency, and their ability to get there—in a hurry—is both a tribute to their sleek design and to the highly efficient engines which power them. Behind the whirling propellers which speed these craft through the water are gears—Foote Bros. gears of such extreme precision that until a short time ago, they were considered a laboratory product.

But engines for rescue boats and torpedo boats—engines for fighters, bombers and aerial freighters, called for gears in such quantities that only mass production methods could supply the demand.

And today these "jewels of power transmission" are flowing out in ever-increasing quantities to speed America's fighting forces—in the air and on the waves—to Victory.

The new manufacturing techniques, and new ways of coupling extreme precision with mass production developed in the plant of Foote Bros. mean more and better aircraft and marine engines. These same lessons applied to the world of tomorrow will mean better machines, more compact and more efficient machines produced at costs that promise greater savings to America's manufacturers.

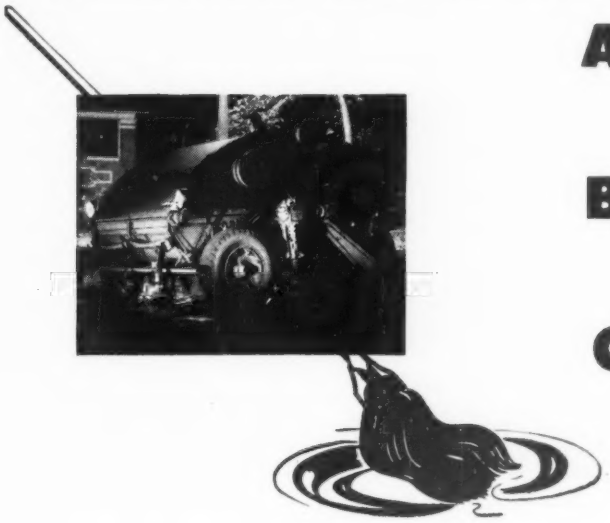
FOOTE BROS. GEAR AND MACHINE CORPORATION
5301 South Western Boulevard
CHICAGO

FOOTE BROS.

Better Power Transmission Through Better Gears

HOW to design the power transmission for a "mechanized mop!"

This machine, whose every function is inter-related, offered these three problems:



A *Driving:* power must be used efficiently—through long or short center distances.

B *Speed ratios* of brush, conveyors, elevators, must be maintained accurately.

C *Conveyors* and elevators must work continuously with little maintenance.

Why use BALDWIN Roller Chain Belts?

● Baldwin roller chain belts were used on this intricate street sweeper because they provide 98.6% efficiency; positive maintenance of speed ratios; great ability to absorb shock and equal efficiency whether operating on long or short centers. Finally, and of equal interest to your customers as well as to yourself, they are easy to install or repair.

Call the Baldwin man to cooperate with your engineering staff when designing machinery which involves problems of driving, timing or conveying. Baldwin-Duckworth Division of Chain Belt Company, 320 Plainfield Street, Springfield, Mass.

PLEASE NOTE

Baldwin roller chain belts transmit power between shafts with nearly 100% efficiency, yet absorb shocks and stand up under conditions of heat, abrasion and corrosion that seriously impair other power transmission media.

★

POSITIVE!

THAT'S BALDWIN ROLLER CHAIN BELTS

MADISON-KIPP

TRADE MARK REG. U.S. PAT. OFF.

hi-high

pressure

ALUMINUM DIE CASTINGS

for Army and Navy Parts

Since the invention of the Madison-Kipp hi-high pressure casting process the possibilities for Aluminum die casting usage has been vastly extended. For some of the largest civilian projects in Aluminum, hi-high pressure castings were adopted to the exclusion of all other types of castings because of their high quality and performance.

For many vital Ordnance components, the hi-high pressure process established Aluminum die castings as the most satisfactory and most economical specification. Aluminum is a light, cheap metal. The Madison-Kipp hi-high pressure process makes possible a wide application of it — and probably to your own requirements.

MADISON-KIPP CORPORATION
204 Waubesa Street, Madison, Wis., U. S. A.
Complete DIE CASTING SERVICE · FRESH OIL LUBRICATORS · HIGH SPEED AIR TOOLS

THIS ELIMINATES THIS!

THE OLD WAY
Right hand reaching for lock washer and left hand for screw and bringing them together to assemble.
Placing assembled unit in position with left hand and bringing driver towards work with right
THE SEMS WAY
Left hand picks up SEMS Fastener Unit and places it while right hand is free to handle driver.

Candid Proof

OF IMPORTANT TIME SAVINGS!

The camera tells you how SEMS Fastener Units save vital production time. No wasted motions—no chance to "forget" the lock washer! A perfect fastening for "green" workers. With only one unit to handle, it speeds driving! Inventories always balance and one order covers both parts. Take advantage of this pre-assembled unit—let your workers try it! Handy kits of assorted testing samples are ready—write for yours now!

SHAKEPROOF inc.

"FASTENING HEADQUARTERS"

2501 North Keeler Avenue, Chicago, Illinois

Distributor of Shakeproof Products Manufactured by
ILLINOIS TOOL WORKS

In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

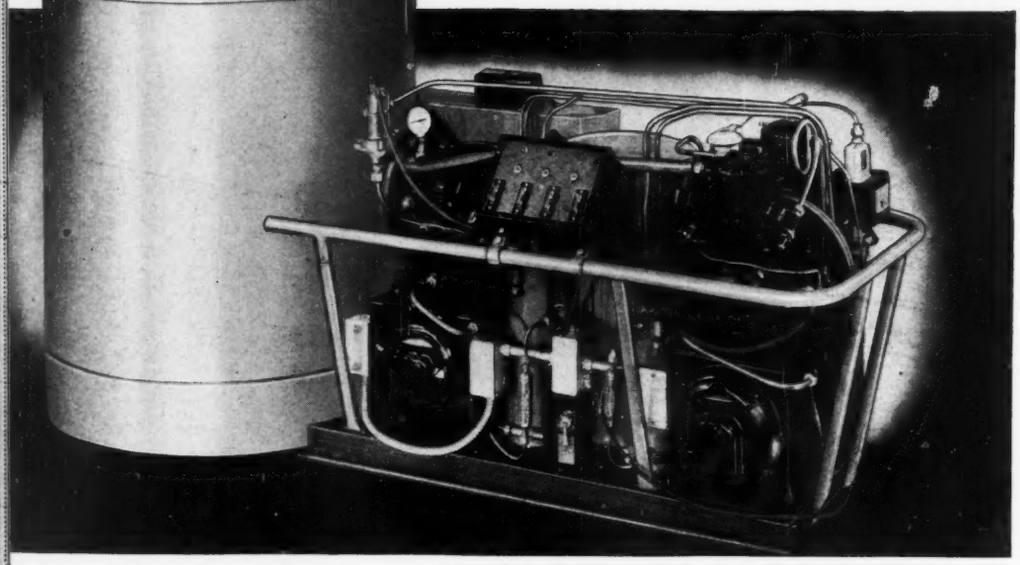
SEMS FASTENER UNITS • THREAD-CUTTING SCREWS • LOCK WASHERS • COWL FASTENERS • LOCKING AND PLAIN TERMINALS • LOCKING SCREWS • RADIO AND INSTRUMENT GEARS • SPECIAL STAMPINGS

SEMS

REG. U. S. PAT. OFF.

FASTENER UNITS

PRE-ASSEMBLED SHAKEPROOF LOCK WASHER AND SCREW



Deepfreeze Santocel Cascade Industrial Chilling Unit. Capable of maintaining temperatures as low as —120° Fahrenheit.

Removes 1000 B.T.U.'s Per Hour at —120° F.

Effects Savings Up To $2825 Per Year Over Dry Ice

In addition to eliminating the inconvenience of handling dry ice, the Deepfreeze Cascade Chilling Unit produces and maintains a temperature substantially 29 degrees colder. Laboratory tests prove that the cost for removing 1000 B.t.u.'s per 24-hour day over a period of one year with dry ice is $3000.00, as compared to the $175.00 electric current consumption of the Deepfreeze over the same period of time.

THE DEEPFREEZE STANDARD CASCADE INDUSTRIAL CHILLING UNIT has a chilling chamber 24" in diameter by 30" deep. It is equipped with two motors and two compressors of the silent-valve-head, water-cooled, piston type. It has a heat absorbing capacity equivalent to 196 lbs. of dry ice per 24-hour day under similar operating conditions.

The same standard unit can be furnished 60" deep or deeper.

How to Use Sub-zero Temperatures in Metal Working

. . . Deepfreeze Metal Chilling Increases Production Efficiency in Fabricating Tool Steel, Bronze, Brass, Aluminum and Magnesium Parts . . .

MANY long-recognized metal working problems are finding solution in industry's newest helper—*Metal Chilling.* Among its unlimited uses are the following:

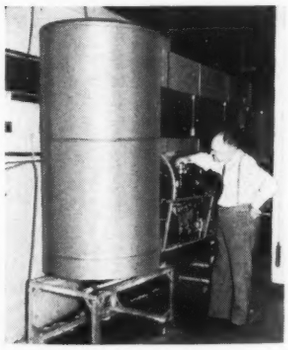
Shrinking of Metal at —100° F. to —120° F. has made it possible to assemble bearings and similar parts requiring a press-fit by merely slipping them into position . . . eliminates spoilage caused by "pounding" bearings into place . . . saves time caused by delay in replacing bearings . . . saves cost of expensive equipment.

Another application is in chilling aluminum alloy rivets 17S-T and 24S-T to retard aging. Rivets can be kept soft enough for driving for a period of over two weeks.

Testing of Metals at —100° F. to —120° F. has made it possible to study the reactions of aircraft instruments to stratosphere flying. Aircraft engine lubricants can also be pretested for sub-zero flying. Tests are usually conducted over a 6 or 8-hour freezing period.

Treating of Metal at —100° F. to —120° F. will produce combinations of hardness, strength and ductility not obtainable by ordinary hardening or tempering. "For treatment of high-speed steel, temperatures colder than —150° F. are ineffective. Temperatures *warmer* than —100° F. are also ineffective."

The Deepfreeze Cascade Unit is capable of maintaining —120° F., making it ideal for the proper treatment of high-speed steel.



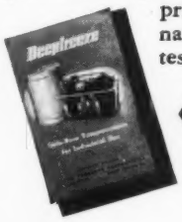
Special Units Designed for Specific Needs

In addition to the standard Deepfreeze units, special units can be designed to suit specific applications. Extra deep chilling compartments have been furnished for shrinking airplane retractable landing gear parts in assembly. Many other designs are being furnished, each to suit a specific problem.

Other special designs have been furnished for desiccating blood plasma, shell freezing blood plasma, and for testing aircraft instruments at all flying levels and temperatures.

FREE ENGINEERING ASSISTANCE

Deepfreeze engineers are available to assist you in obtaining the advantages of sub-zero metal conditioning. Send us an outline of your problems, together with parts or prints for a preliminary calculation and test—no obligation.



FREE DATA *and proof of the outstanding success of the Deepfreeze method for chilling metals is included in this booklet. Write for your copy today.*

Deepfreeze

DIVISION

MOTOR PRODUCTS CORPORATION

2329 DAVIS STREET, NORTH CHICAGO, ILLINOIS

How to calculate Rate of Heat Flow through Metallic Walls

As a result of work done by INCO Technical Service, a new booklet, "Heat Transfer through Metallic Walls," has recently been printed.

It explains in detail how to calculate heat transfer, and covers conductance values of film, scale, and condensing vapor film. It also includes tables on thermal conductivity of various metals, conductance ranges for metallic walls and films and other phases of the subject.

A valuable section of "Heat Transfer through Metallic Walls" consists of charts on heat transfer co-efficients for 11 different metals:

Copper	Lead
Aluminum (2S)	Cupro Nickel (70-30)
Red Brass (85-15)	Monel
Admiralty Brass	Inconel
Mild Steel (SAE 1020)	Stainless Steel (Type 430)
Nickel	Stainless Steel (Types 304, 316, 321)

In addition to the information contained in this bulletin, INCO Technical Service will gladly furnish personal assistance in the solution of specific heat transfer problems.

For copies of "Heat Transfer through Metallic Walls" please mail the coupon below.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York, N. Y.

Gentlemen:

Please send me.....copies of your bulletin, "Heat Transfer through Metallic Walls" to:

Name.....

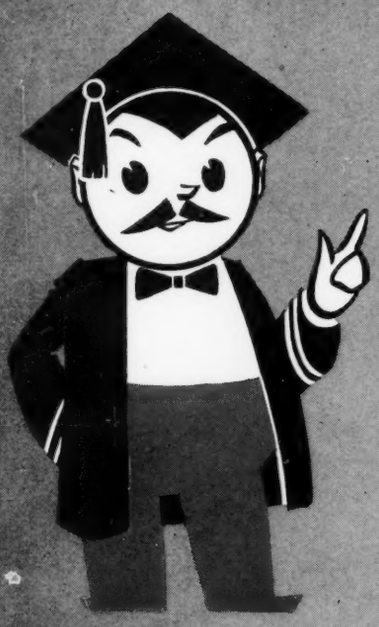
Title.....

Company.....

M. D. 12-42

Address.....

PROFESSOR QUIZ ASKS A QUESTION-



THE QUESTION:

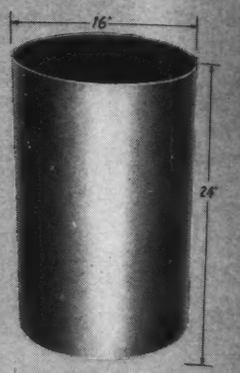
What Do You Know About Deep Drawn Shapes?

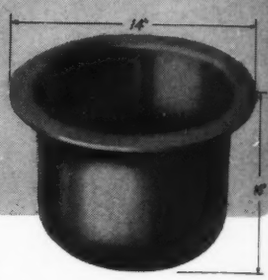
WHERE ASKED:

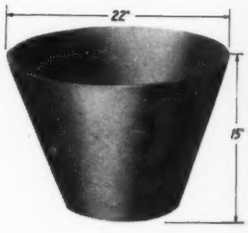
Any Plant in the Many War Industries Where Hackney Deep Drawn Shapes Are Used.

WHO WAS ASKED:

Engineers Now Planning Vital War Production.







● *J— C—, Engineer for an airplane parts manufacturer.* Our business calls for precision work. That's why we use Pressed Steel Tank Company Shapes. Hackney shapes assure a smooth finish, uniform thickness and temper. Also, all possibilities of flaws or laminations are eliminated in the finished product.

● *A— H—, Engineer for munitions firm.* By using Hackney Special Deep Drawn Shapes we were able to step up production. They were easier to handle—and through their use it was possible to eliminate other operations. Many times Hackney welding and deep drawing have been of substantial aid on other manufacturing processes. Then, too, Hackney Deep Drawn Shapes or Shells assured increased strength while they reduced overall weight.

● *B— W—, Engineer, Chemical Concern.* The advantages of Hackney Deep Drawn Shapes and Shells have caused us to specify them for years. We know we are dealing with experience when we come to Pressed Steel Tank Company. They have been specialists in the manufacture of Seamless Deep Drawn Shapes and Shells for more than 40 years. We know that they have dies and equipment to handle shapes and shells classed as "out of the ordinary." They have been made as small as one quart and as large as 110 gallon capacity.

● *D— M—, Engineer, Process Industry.* We have been able to solve many of our engineering problems by the use of Hackney Special Deep Drawn Shapes or Shells. I would advise anyone having a problem involving the use of Seamless Deep Drawn Tubes, Shells, special cylindrical shapes or pressure tanks to write to Pressed Steel Tank Company. Their long years of experience make it possible for Hackney engineers to make many important suggestions. And, of course, there is no obligation.

PRESSED STEEL TANK COMPANY

General Offices and Plants: 1433 South 66th Street, Milwaukee, Wisconsin

HACKNEY DEEP-DRAWN SHAPES AND SHELLS

Hackney MILWAUKEE

Containers for Gases, Liquids and Solids

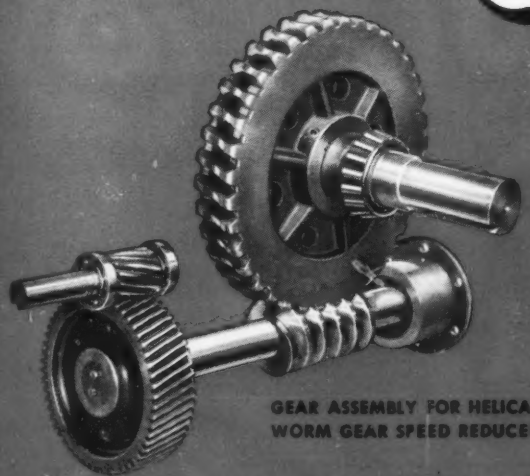
CONTINUOUS-TOOTH HERRINGBONE GEAR AND PINION

"General GEAR"
IS A FIGHTER TOO...

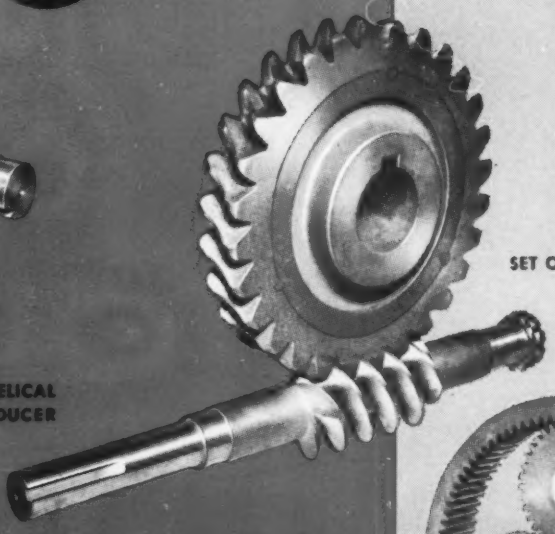
★ He's the guy that makes the Jeeps Jump... He's also the BIG-WORKS in the tank, battleship or airplane... in fact he's the BIG-WORKS in any Power-saving or Power-driving Machinery. HE'S GOTTA BE GOOD. Our organization of many years of Gear Making Experience is going to keep him fighting and to help keep all of us on top.

D.O.James

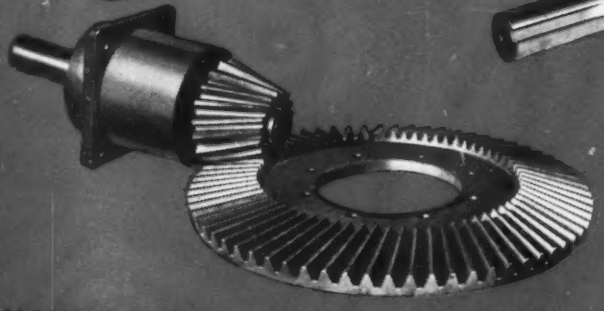
D. O. JAMES MANUFACTURING CO. 1140 WEST MONROE ST., CHICAGO, ILLINOIS



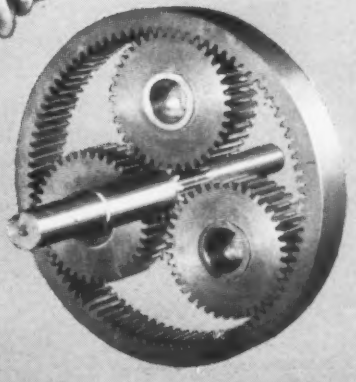
GEAR ASSEMBLY FOR HELICAL WORM GEAR SPEED REDUCER



SET OF WORM GEARS



A SET OF SPIRAL BEVEL GEARS WITH PINION BEARING MOUNTING



A SET OF PLANETARY GEARS

MAKERS OF EVERY TYPE OF GEAR AND GEAR REDUCER

to help YOU do a

in the production of STAINLESS PARTS

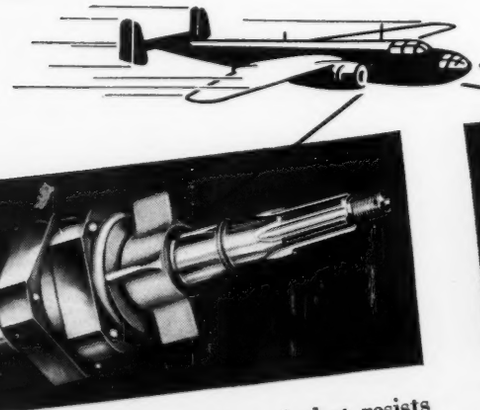
➧ ***HINTS*** **on how to get the most from every pound of Stainless Steel you use.**

➧ ***TIPS*** **on how to increase production, how to do the job better.**

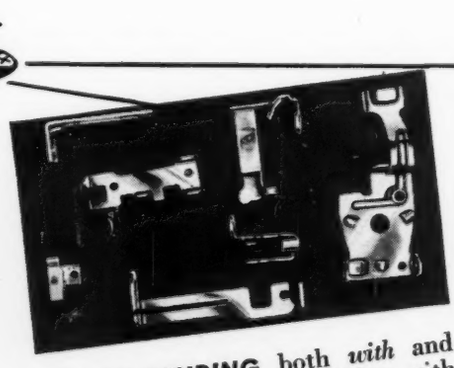
You and your men no doubt know many short-cuts as a result of your experience in fabricating Stainless Steel. We'd like to help you add to that knowledge by giving you the benefit of our experience in solving Stainless problems.

So we are passing along some of the suggestions collected from Carpenter metallurgists, research men and service representatives. Most of these men have devoted a good part of their lives to solving Stainless problems. Today, through their efforts, better and faster fabricating methods are available to war production plants.

In many of these plants, Carpenter men are being asked to solve special corrosion and heat resistance problems . . . and then work out faster fabricating methods. Because time is short, they can not be everywhere at once. But much of their experience can be made available to you through these pages, and by correspondence with the mill . . . Write us about your specific Stainless problems.



EASY-TO-MACHINE steel that resists corrosion is needed for making magneto shafts like this . . . so Carpenter Free-Machining Stainless is used to eliminate many production headaches.



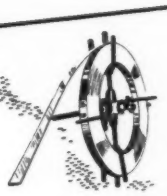
SEVERE BENDING both *with* and *against* the grain is no problem with soft and ductile Carpenter Stainless Strip. Then too, these switch parts must be made to close tolerances — with fewer rejects — an easier job with this Stainless Strip.

TERRIFIC HEAT and corrosion "gang up" on airplane exhaust manifolds—so Stainless is used to make the trip "home" possible. (And it is here that the high strength/weight ratio of Stainless improves product performance.)

a trouble-shooting job

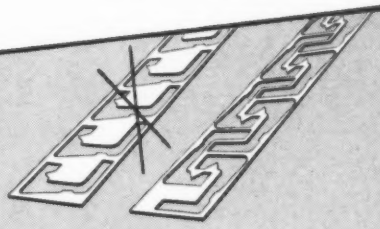
Just Press Speeds For MORE Output!

...ps your press speeds are OK. ...be faster speeds should be ... A quick check-up may even ...that a reduction of 10 to 15% ...d increase output and con... metals. Often, slower press ...eds will overcome die galling ...t can spoil parts and interrupt ...duction.



Saved: 30,000 Pounds of Stainless!

From 45,000 lbs. of Stainless Sheet to only 15,000 lbs. of narrow Stainless Strip—for making the same number of parts! Saved: 30,000 lbs. of vital metal, *and* the time required to slit and handle sheet. Check the use of narrow Strip on your jobs where Sheet is used.

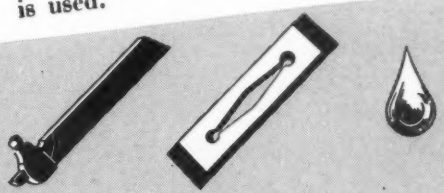


Re-Check Layouts ---NOW!

Keep your skeleton scrap losses to an absolute minimum. Spend a few hours now to re-check layouts on jobs that are stamped from Strip. The results will be well worthwhile . . . in terms of metal conserved and time saved.

"Tell All" to Your Supplier . . .

Tell your supplier about your punch press problems, your machining difficulties and high percentage of rejects. He made the material you use, and can probably offer plenty of good, solid help and useful information.



How About . . . Tools? . . . Dies? . . . Lubricants?

Frequently, an analysis of your tool, die and lubricant set-up will point the way to getting rid of tough production "bugs". A complete review of procedure can do a lot to help you boost output and conserve much-needed metals.

"Much scrap. So happy." Check Your Rejects . . .

Material that is not uniform throughout can cause many a headache such as wrinkling in the die. Tearing and galling can also result from using off-size material. But *whenever* rejects are high, it pays you to check *all along the line.*

AND remember that your Carpenter representative and our Metallurgical Department can provide on-the-spot help . . . to enable you to beat your really tough problems.

The Carpenter Stainless Slide Chart is a useful "assistant" to have at your elbow. It provides data on the welding, heat resisting and machining properties, etc. of each Stainless Steel. A note on your company letterhead will bring you a Carpenter Slide Chart—free to Stainless Steel users in the U.S.A.

THE CARPENTER STEEL COMPANY, 120 Bern Street
Reading, Pennsylvania

more than corrosion resistance

Carpenter STAINLESS STEELS

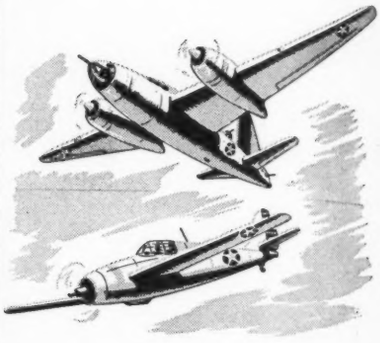
BRANCHES AT Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

THESE LYON FACILITIES

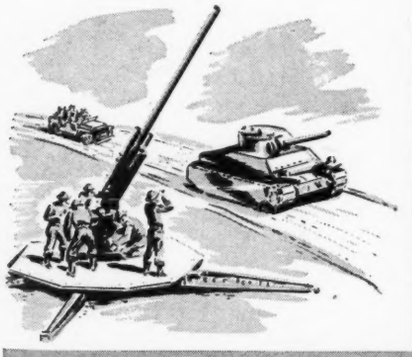
GET THE JOB DONE

When You Want It . . . As You Want It

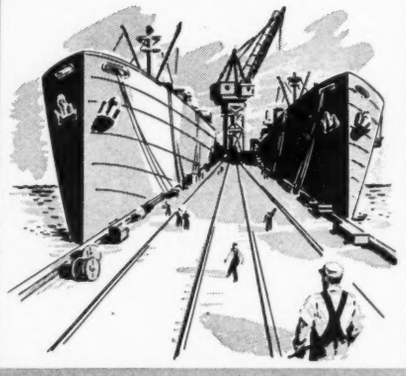
1 Aircraft Aluminum and Steel Parts and Sub-Assemblies



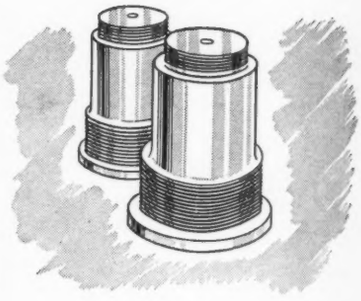
2 Anything in Sheet Steel No. 8 to 30 Gauge



3 Pre-Fabricated Ship Parts and Ship Furniture



4 Conversion of forgings and Castings and Machined Parts to Sheet Metal



5 Alert Management, Skilled Workers, Complete Facilities

1. **Aircraft:** Capacity available in Aircraft Division for Aluminum parts and sub-assemblies.
2. **Sheet Steel:** 42 years experience in fabricating steel—over two years on special war products.
3. **Ships:** Experienced Lyon Engineers are working daily with architects and ship builders on pre-fabricated parts and furniture.
4. **Conversion—Forgings, Castings and Machined Parts:** Proven ability to adapt sheet metal machines and experience to redesign of "bottle-neck" processes. One typical conversion saving 210,000 machine tool hours.
5. **Know-How:** Experienced development, design and engineering staffs. Complete toolrooms in all plants. Send for book, "Craftsmen in War Production."

LYON METAL PRODUCTS, INCORPORATED

General Offices 812 Madison Avenue, Aurora, Illinois

Sales and District Offices Manned by Experienced Engineers in All Principal Cities

LYON METAL PRODUCTS, INCORPORATED

BEARINGS THAT FLY

Must Have "What It Takes"

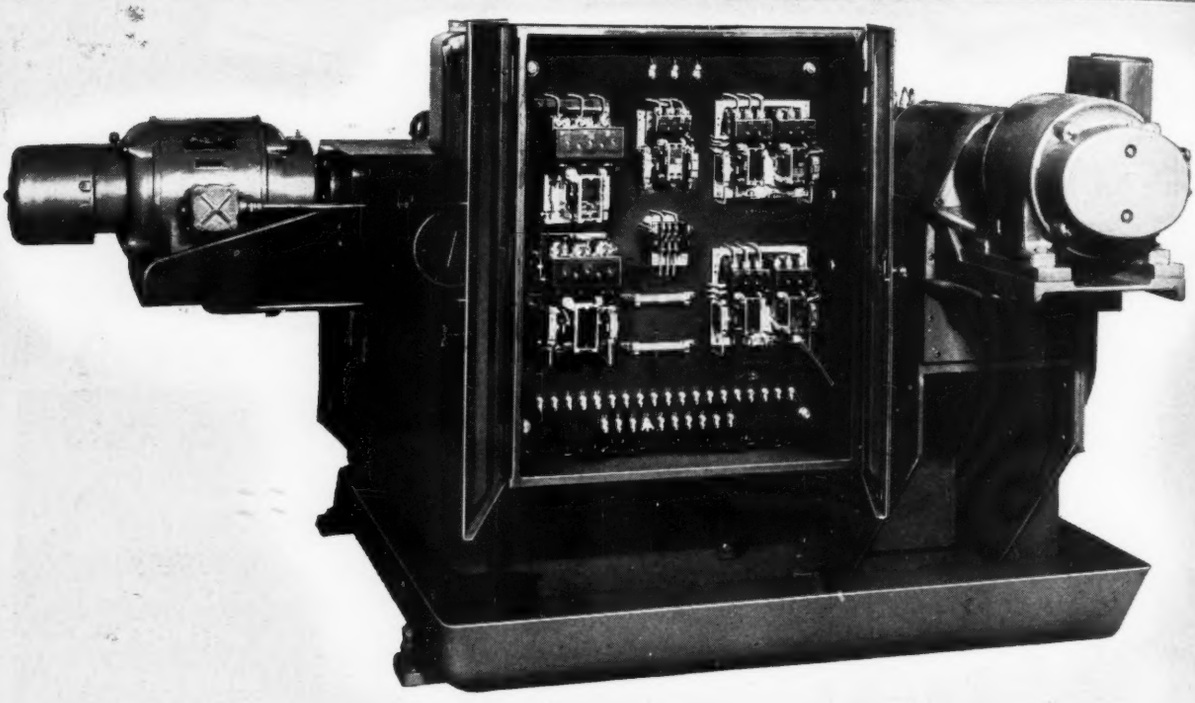
This remarkable new testing device is built on tracks that permit aircraft engines to be operated in positions of actual flight.

No other application in mechanical history has ever demanded so much from bearings of the size and weight of those supplied by Bunting for modern aircraft engines. New and unprecedented limits are imposed on all operations in the manufacture of these bearings. If unusual requirements today involve a bearing problem, Bunting experience and resources can aid you. The Bunting Brass & Bronze Company, Toledo, Ohio. Warehouses in All Principal Cities.

Bunting

BRONZE BUSHINGS • BEARINGS • PRECISION BRONZE BARS

CONTROL FOR ALMOST ANY MACHINE TOOL CAN BE ASSEMBLED FROM STANDARD UNITS LISTED IN THE SQUARE D CATALOG



Whether you build them or we build them, control panels assembled from standard Square D units are compact, neat appearing and dependable, because every device is specifically designed for machine tool service. Listed in the Square D catalog are many complete lines of contactors, starters, relays, timers and accessories for the control of machine tool electrical functions.

Each unit, while designed to do its own job properly, is also physically proportioned for easy combination with other units in making up control panels. Uniform construction and regularity of shape and size assure compactness, pleasing appearance and complete accessibility.

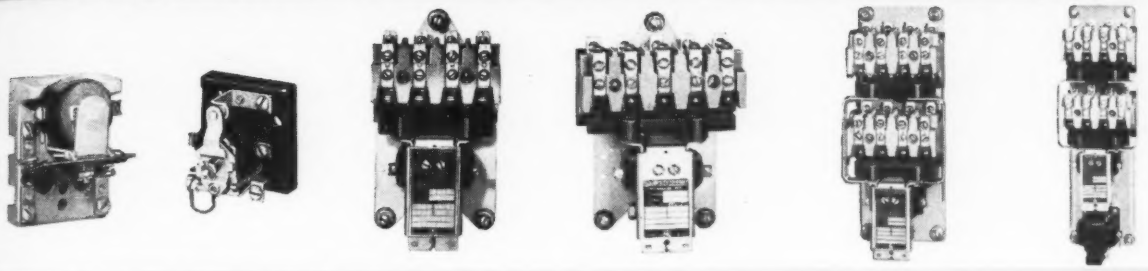
Square D's line of D.C. control parallels its A.C. equipment in completeness and versatility. Thus, you can look to Square D for almost any machine tool control requirement, whether it be standard or special, A.C., D.C., or a combination of both.

SQUARE D COMPANY

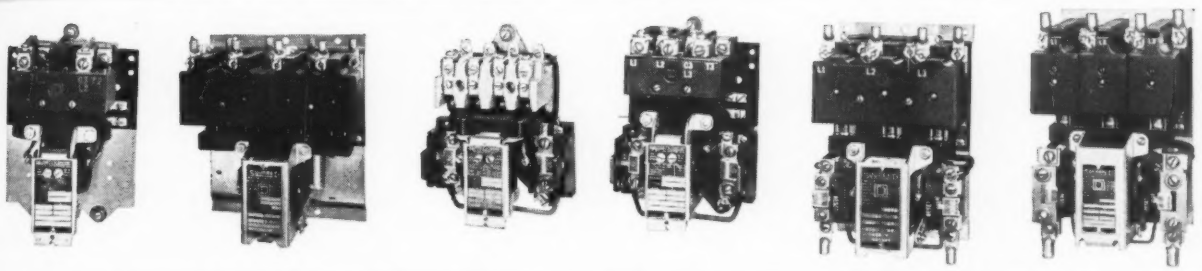
DETROIT - MILWAUKEE - LOS ANGELES

KOLLSMAN INSTRUMENT DIVISION, ELMHURST, NEW YORK

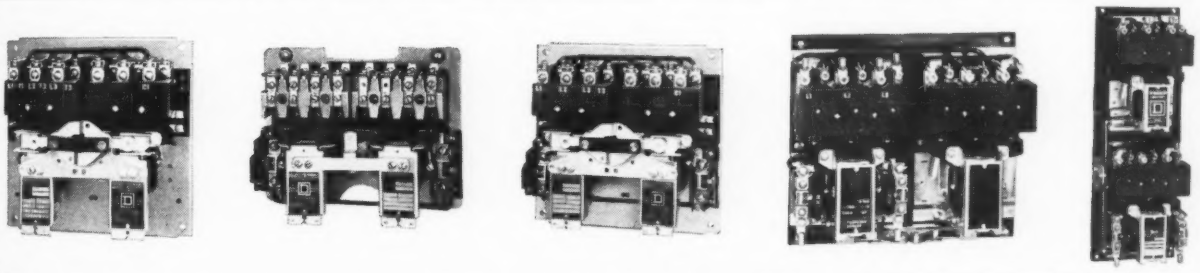
IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO



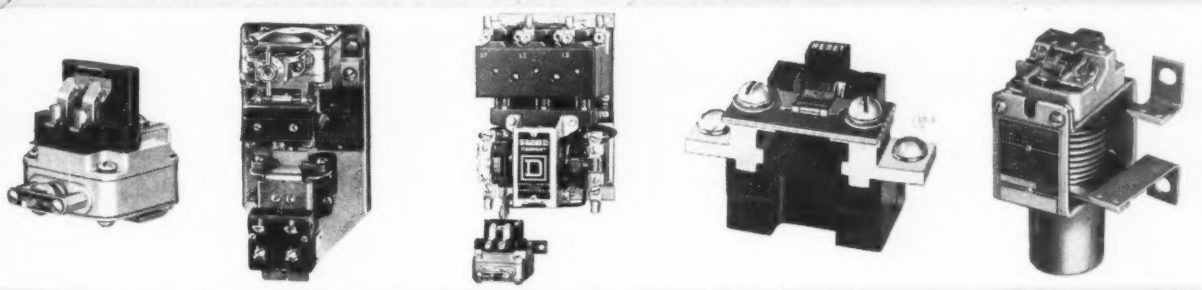
CONTROL RELAYS – TWO TO EIGHT N.O. OR N.C. POLES – MAGNETIC OR MECHANICALLY HELD



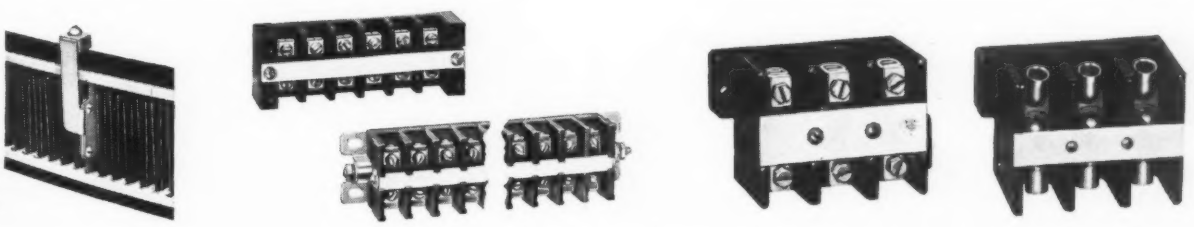
VERTICAL ACTION CONTACTORS AND STARTERS – WITH DOUBLE BREAK SILVER CONTACTS



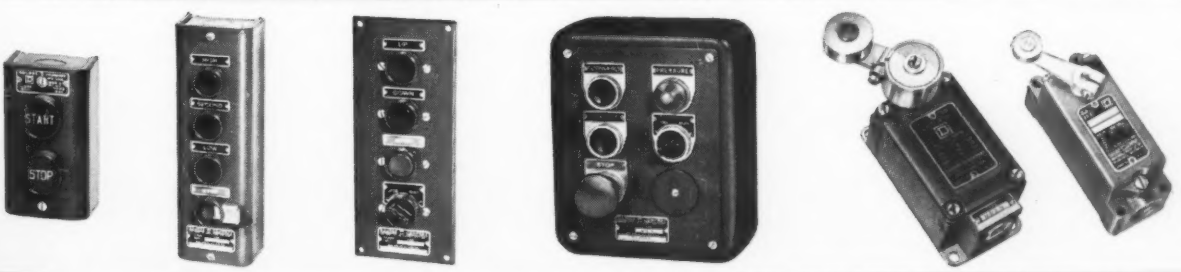
REVERSING CONTACTORS AND STARTERS WITH HORIZONTAL OR VERTICAL ARRANGEMENTS



PNEUMATIC TIMING RELAYS – (.2 SEC. - 3 MIN.) – THERMAL AND MAGNETIC OVERLOAD RELAYS



EDGEREST RESISTOR UNITS – TERMINAL BLOCKS HAVING THREE TO TWENTY-FOUR CIRCUITS



ONE TO SIXTEEN UNIT CONTROL STATIONS – LARGE AND SMALL PRECISION LIMIT SWITCHES

Around the Clock—the Months —the Years

In quieter times, performance was measured in hours, months, years. Now, *minutes* are the unit. Cleveland Worm Gear Speed Reducers make every minute count by keeping machines in continuous operation.

You no doubt have been impressed by the frequent comment "we have no shutdowns," by others who have bought scores or hundreds of Clevelands.

Many of these customers installed their first Cleveland Units 15 to 20 years ago on applications subject to heavy shock loads, yet have had no need for replacement or maintenance at any time.

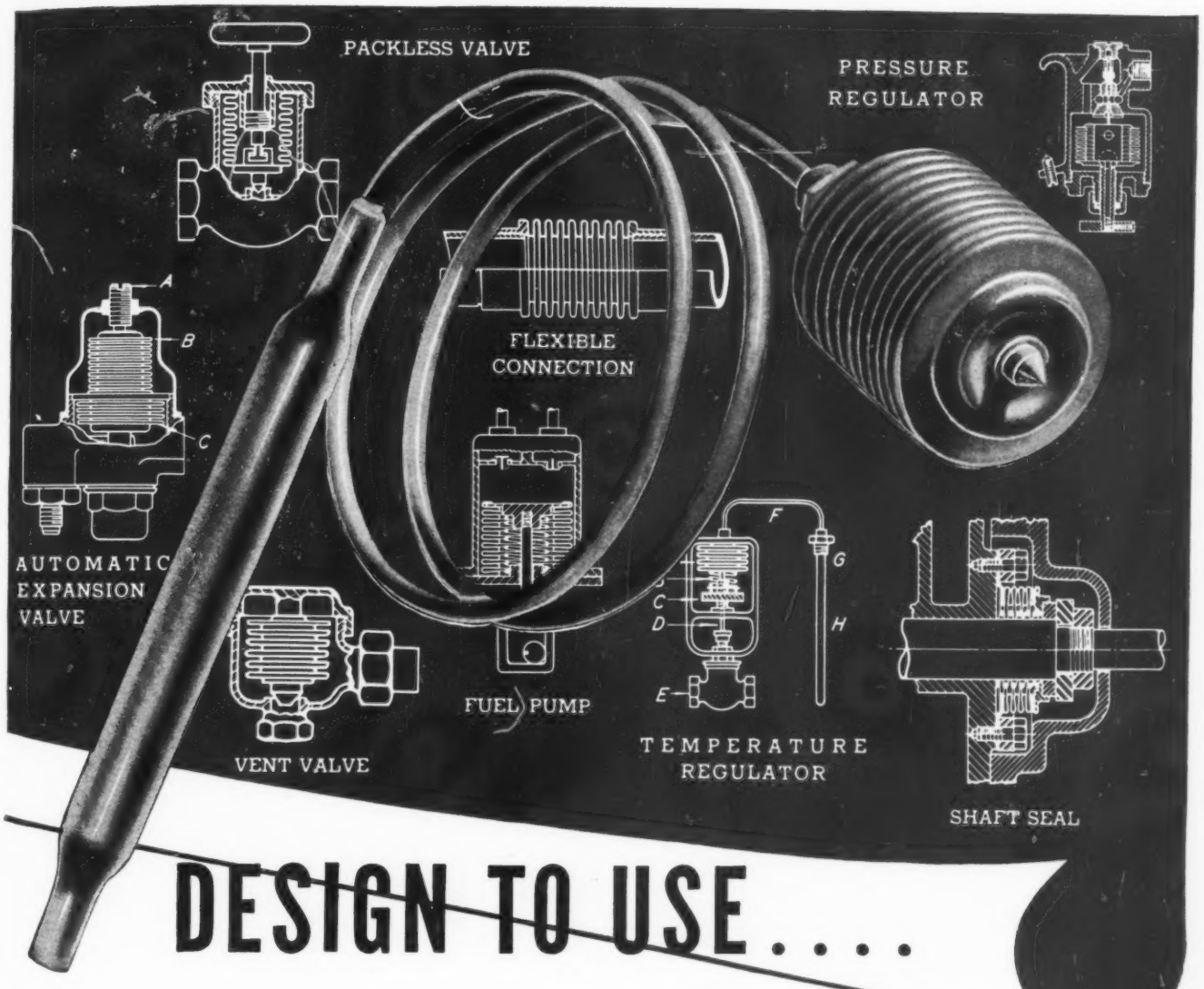
Count on Clevelands to keep *your* machines going. The same caliber of Engineering ability that has developed standard and special Cleveland Worm Gear Speed Reducers for 30 years, is available for applying them to the equipment you build.

The Cleveland Worm & Gear Co., 3265 E. 80th Street, Cleveland, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication

In Canada: PEACOCK BROTHERS LIMITED

CLEVELAND WORM GEAR *Speed Reducers*



DESIGN TO USE....

Sylphon Bellows

New products created, old products improved . . . designers in practically every field use Sylphon Bellows to advantage.

In Sylphon Thermostat Assemblies, for instance, this amazing metal diaphragm helps solve the problems of temperature control in refrigeration, heating, air conditioning and industrial processing.

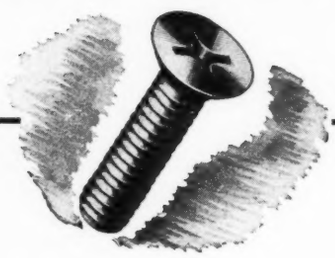
As highly efficient diaphragms used to convert pressure effects into controlled movement in instruments, appliances and machines of various types . . . as flexible seals, expansion chambers, rotating shaft seals, packless glands and for endless similar purposes, the Sylphon Seamless Metal Bellows is constantly replacing less durable, less dependable materials in the products of leading manufacturers.

Sylphon Bellows were pioneered 40 years ago by The Fulton Sylphon Co. Tried and proved, many millions of units are now in service. Quite possibly you have a problem which finds its right answer in Sylphon Bellows—the modern "Miracle in Metal." Write today for Bulletin XC-535

THE FULTON SYLPHON CO.
KNOXVILLE, TENNESSEE
Representatives in All Principal Cities in U. S. A. and in Montreal, Canada and London, England

Now You Have

19 Sources of Supply for Phillips Recessed Head Screws



AMERICAN SCREW COMPANY
Providence, Rhode Island

THE BRISTOL COMPANY
Waterbury, Connecticut

CENTRAL SCREW COMPANY
Chicago, Illinois

CHANDLER PRODUCTS CORP.
Cleveland, Ohio

CONTINENTAL SCREW COMPANY
New Bedford, Massachusetts

THE CORBIN SCREW CORPORATION
New Britain, Connecticut

INTERNATIONAL SCREW COMPANY
Detroit, Michigan

THE LAMSON & SESSIONS COMPANY
Cleveland, Ohio

THE NATIONAL SCREW & MFG. CO.
Cleveland, Ohio

NEW ENGLAND SCREW COMPANY
Keene, New Hampshire

THE CHARLES PARKER COMPANY
Meriden, Connecticut

PARKER-KALON CORPORATION
New York, New York

PAWTUCKET SCREW COMPANY
Pawtucket, Rhode Island

PHEOLL MANUFACTURING COMPANY
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RUSSELL, BURDSALL & WARD BOLT & NUT COMPANY
Port Chester, New York

SCOVILL MANUFACTURING CO.
Waterbury, Connecticut

SHAKEPROOF INC.
Chicago, Illinois

THE SOUTHINGTON HARDWARE MFG. CO.
Southington, Connecticut

WHITNEY SCREW CORPORATION
Nashua, New Hampshire

Your screw requirements can be met without delay — with genuine fast-starting, quick-driving, tight-seating Phillips Recessed Head Screws. ***WHAT ABOUT DRIVERS?*** There are 44 sources of supply for PHILLIPS DRIVERS plus general hardware and mill supply distribution.

PHILLIPS RECESSED HEAD SCREWS

GIVE YOU *2 for 1* **(*SPEED AT LOWER COST*)**

WOOD SCREWS • MACHINE SCREWS • SHEET METAL SCREWS • STOVE BOLTS
SPECIAL THREAD-CUTTING SCREWS • SCREWS WITH LOCK WASHERS

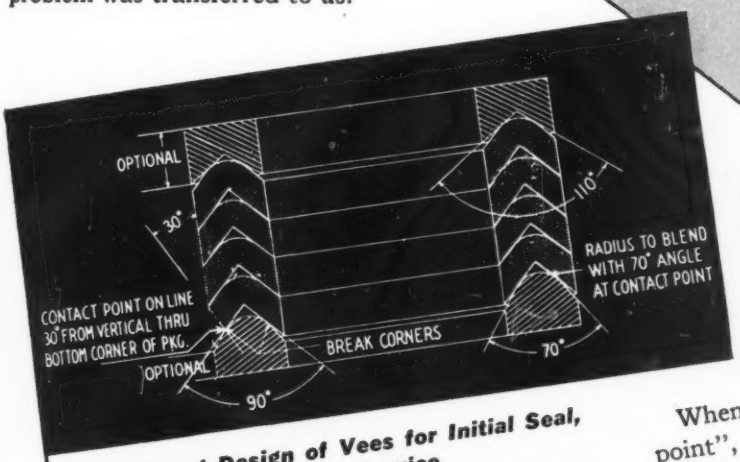
STUCK IN A STUFFING BOX TILL HE READ AN AD LIKE THIS

We can't tell you the product, for that's a military secret.

We can tell you the problem, for you may have one like it.

With stuffing box space limited, the machine builder wondered, "Are 1½" O.D. x ¾" I.D. Vee packings practicable with a 25/32" diameter piston rod; what minimum number will seal 2250 lbs. of oil pressure at normal room temperatures?" Also, "What size adapter rings?"

Just then, an issue of this magazine arrived, carrying an ad telling how Graton & Knight Packing Engineers helped a designer in a jam at the "packing point". So the problem was transferred to us.



Correct Design of Vees for Initial Seal, Longer Service

Our engineers' recommendation was four Vee packings 1½" O.D. x 25/32" I.D., made from 3/32" thick Spartan leather; stack height .1325", total stack height .530"

These Vees have a 90° angle, giving a 45° sealing lip. The combination of 70° and 100° adapter ring angles permits the Vees to spread as the pressure comes on. And since the Vees feed to the wear, life is lengthened.

The G & K engineers also noticed cup packings back to back on the piston head. They suggested Vees as promising much better performance — and this recommendation, like the one for the stuffing box, was adopted.

Spartan Leather or GraKone Synthetic Rubber plus G & K Engineering for Success at the Packing Point.

When *your* design reaches the "packing point", ask Graton & Knight for help in selecting the proper material, type and design of packing.

SPARTAN PACKINGS, made from a superchrome leather (chrome plus vegetable tanning), have highest resistance to abrasion and heat, are unaffected by common pressure mediums, and will not dry out hard and brittle.

GRAKONE PACKINGS, made from especially compounded synthetic rubber, are non-porous, non-corrosive, have low permanent set, withstand high temperatures (250° F.).

Spartan Leather Packings

AND GRAKONE SYNTHETIC RUBBER PACKINGS

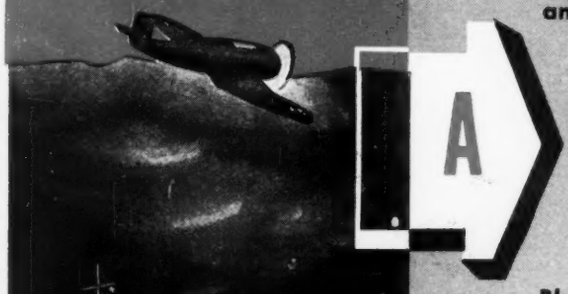
GRATON & KNIGHT CO.

WORCESTER GRATON AND KNIGHT MASSACHUSETTS

GENERATORS

FOR WAR SERVICE

When your war products require generators, come to Leland. The three sets illustrated here are typical examples of the many special problems we have met and solved in this field.



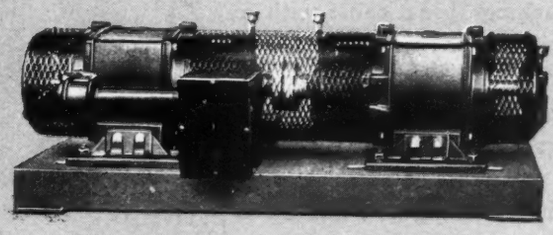


Photo A **. . . shows a special Leland generator for testing electrical aircraft equipment. Originally designed for our own laboratory, it contained so many important features that other companies soon ordered duplicates.**

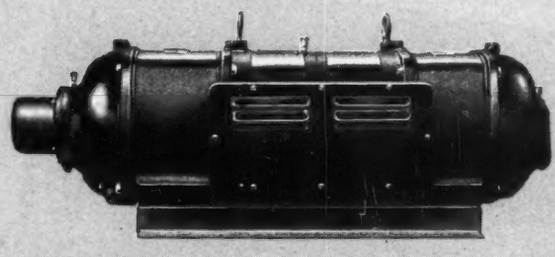


Photo B **. . . shows a special Leland DC to AC shock proof set for marine service. Has a speed governor to control frequency to within 1% variation.**

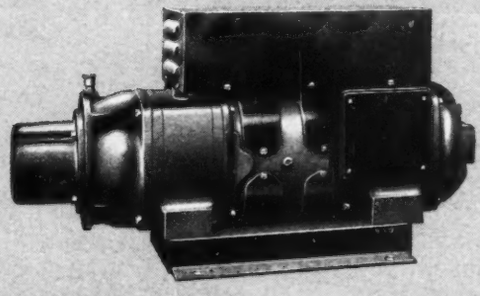


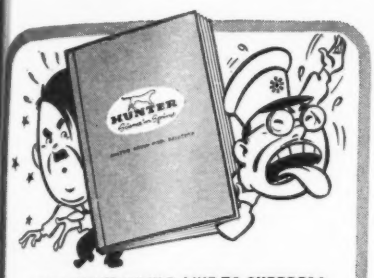
Photo C **. . . shows another special DC to AC Leland shock proof set for marine service. Has a speed governor to control both the frequency to within 1% variation and voltage to within 3%.**

Send your generator problems to Leland. We have the facilities, the experience, and the ability you need.
The Leland Electric Co., Dayton, Ohio.

MOTORS, GENERATORS, INVERTERS, ALTERNATORS.
ALSO STANDARD TYPES FROM 1/20 TO 5 H.P.

LELAND WAR DUTY MOTORS

The SPRING that WINDS ITS TAIL on ITS BODY

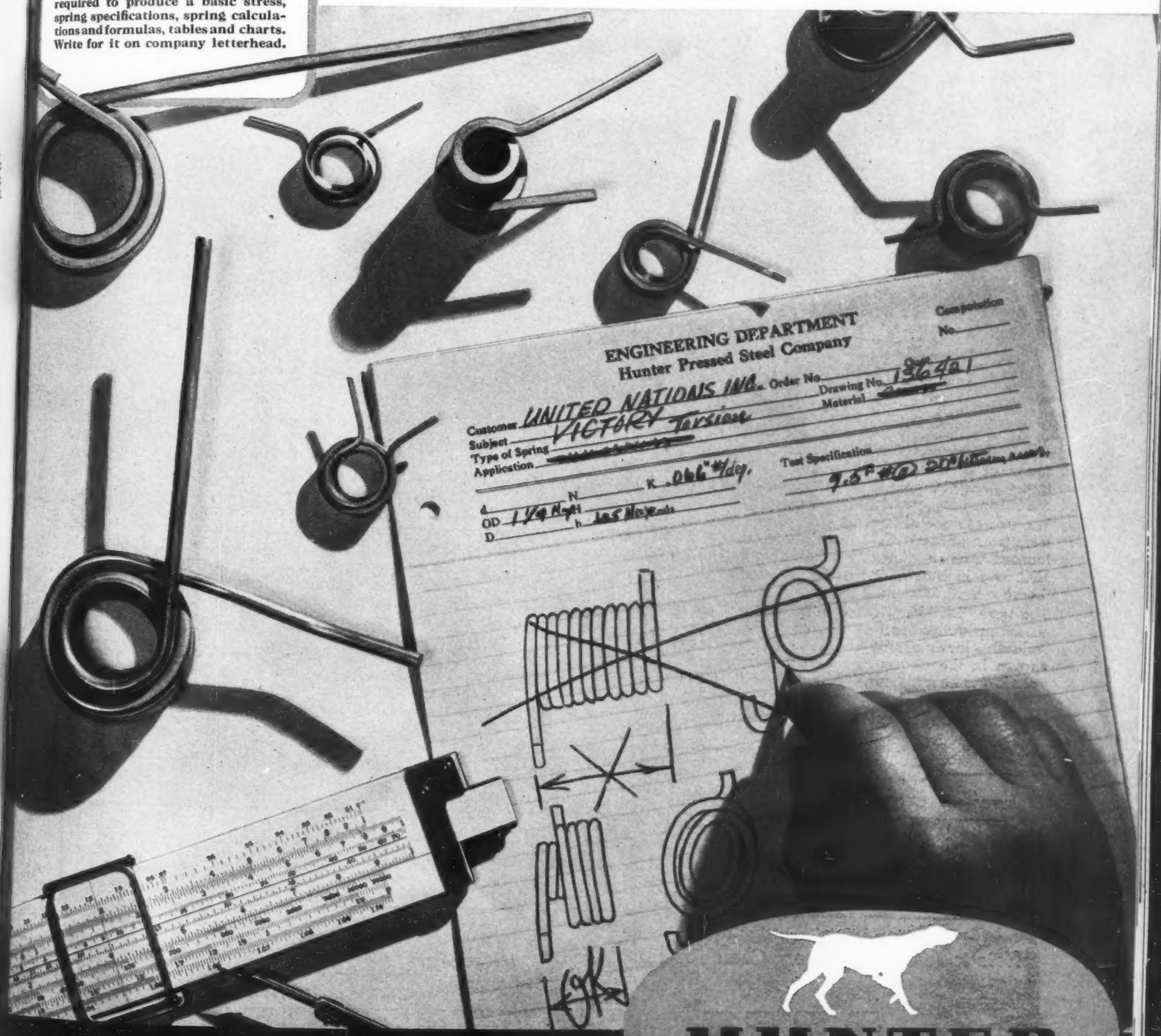


A BOOK HITLER WOULD LIKE TO SUPPRESS
. . . Yours for the asking

SCIENCE IN SPRINGS . . . 40 pages about springs, carefully culled from our master data. Design procedures for springs, the "spring chart" for determining the load and deflection required to produce a basic stress, spring specifications, spring calculations and formulas, tables and charts. Write for it on company letterhead.

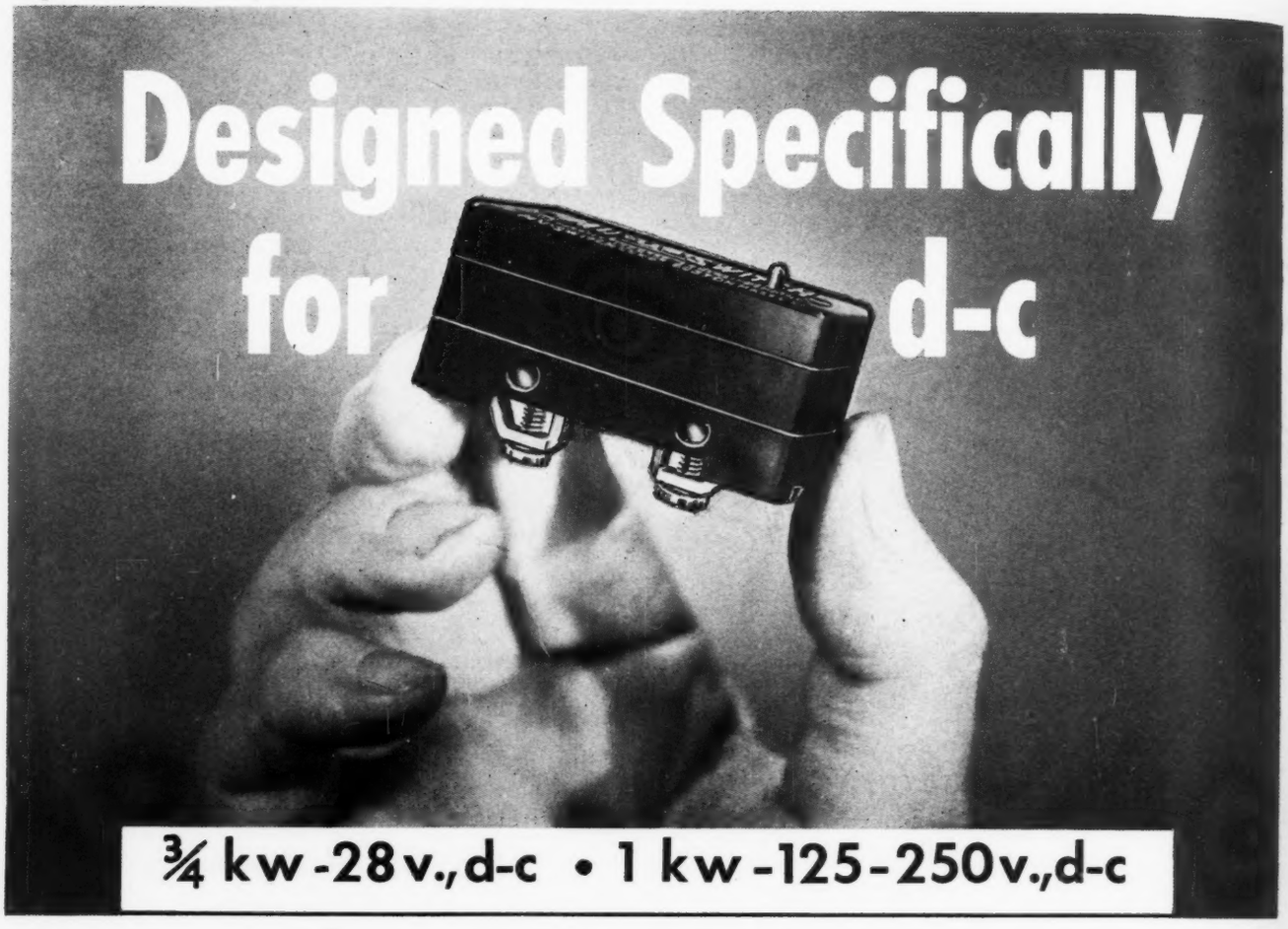
AT TIMES only a torsion spring will do. And only a unique torsion spring at that . . . such as one of the "double-coil" torsion springs below. You see, to achieve proper spring length where the retaining pin or shaft is short, these double springs are coiled over themselves like thread on a spool. Their advantages? Well, apart from their suitability to close quarters, they have other advantages over single-coil torsions, notably—stress is lower, or force is greater, or deflection is greater—assuming that the other two of the three factors are fixed in value. Then again, the double coil inspires a variety of pin locations to avoid interference. . . . Why do we point all this out? Simply to indicate the complexities of spring design and specification. There is only ONE right spring for the job—the one made possible by science in springs.

IN THE ARMY NOW . . . *Springs have gone to the front in a number of ways Hitlerito and his Nipponazis would like to know. If you need springs for fighting equipment, our men will be only too glad to make them or design and make them. Just say when!*



HUNTER
Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.



The type "DX" Mu-Switch is a compact, precision made, sensitive snap-action switch designed specifically to make or break moderate direct current loads with extremely slight travel of the actuating button and relatively light operating pressure.

The use of special contact alloys insures maximum freedom from sticking. A powerful permanent magnet is so located with relation to the contacts that the destructive D.C. arc is blown out and the burning of contacts is thereby held to a minimum.

The type "DX" Mu-Switch will handle up to 30 amperes of non-inductive load at 28 volts at altitudes to 45,000 feet. Inductive loads can be handled successfully at the ratings shown in the charts below. The rating at 125 and 250 volts is one kilowatt, non-inductive load.

The construction is similar to the heavy duty type "D" Mu-Switch but is smaller and lighter throughout. The housing is cold-molded of a special heat resisting composition which has been treated for minimum moisture absorption. Inserts are molded-in, a standard Mu-Switch constructional practise.

The original, patented reverse cross-action spring principle is featured and assures positive action, long life and safe current carrying capacity within the rated load. The spring material is beryllium copper, carefully heat-treated for optimum modulus and minimum drift.

Rigid control and continuous inspection throughout the manufacture of these switches, plus the finest of materials available, assures uniformity and utmost dependability in performance.

The type "DX" Mu-Switch can be supplied with many styles of actuators, brackets and housings.

The operating characteristics can be modified to meet unusual operating requirements.

CHARACTERISTICS CHART — BASIC DIRECT CURRENT MU-SWITCHES

TYPE	CIRCUIT	OPERATING PRESSURE	DIFFERENTIAL PRESSURE	DIFFERENTIAL TRAVEL	ELECTRICAL RATING
D X R	S. P. S. T. Normally Closed	16-28 oz.	8-14 oz.	.0015"-.0035"	¾ kw — 28v., d-c 1 kw — 125 & 250v., d-c
D X G	S. P. S. T. Normally Open				

Note to Aircraft Designers: Greatly increased loads call for heavier duty switches. Type D MU-Switch meets these requirements

MU-SWITCH

MU-SWITCH CORPORATION, 400 PEQUIT STREET, CANTON, MASSACHUSETTS

Mazlo Magnesium products have a reputation for going through production lines a'sailing. Alloys and tempers are correct. Castings are sound and rejections are low. Mighty little labor and machining time are lost when you're working with Mazlo Magnesium products.

Pictured above is a commonplace scene in an American Magnesium foundry. Cores are being checked for position, as they are at every step in building up a mold. Finished castings are also checked point by point. This makes certain that Mazlo castings will be right when your machines start cutting into them.

20 years of working with Magnesium Alloys have taught American Magnesium workmen what it takes to produce dependable products. Add to that knowledge, equipment that's equal to every demand, and a desire to do everything possible to speed war production, and you have the complete picture.

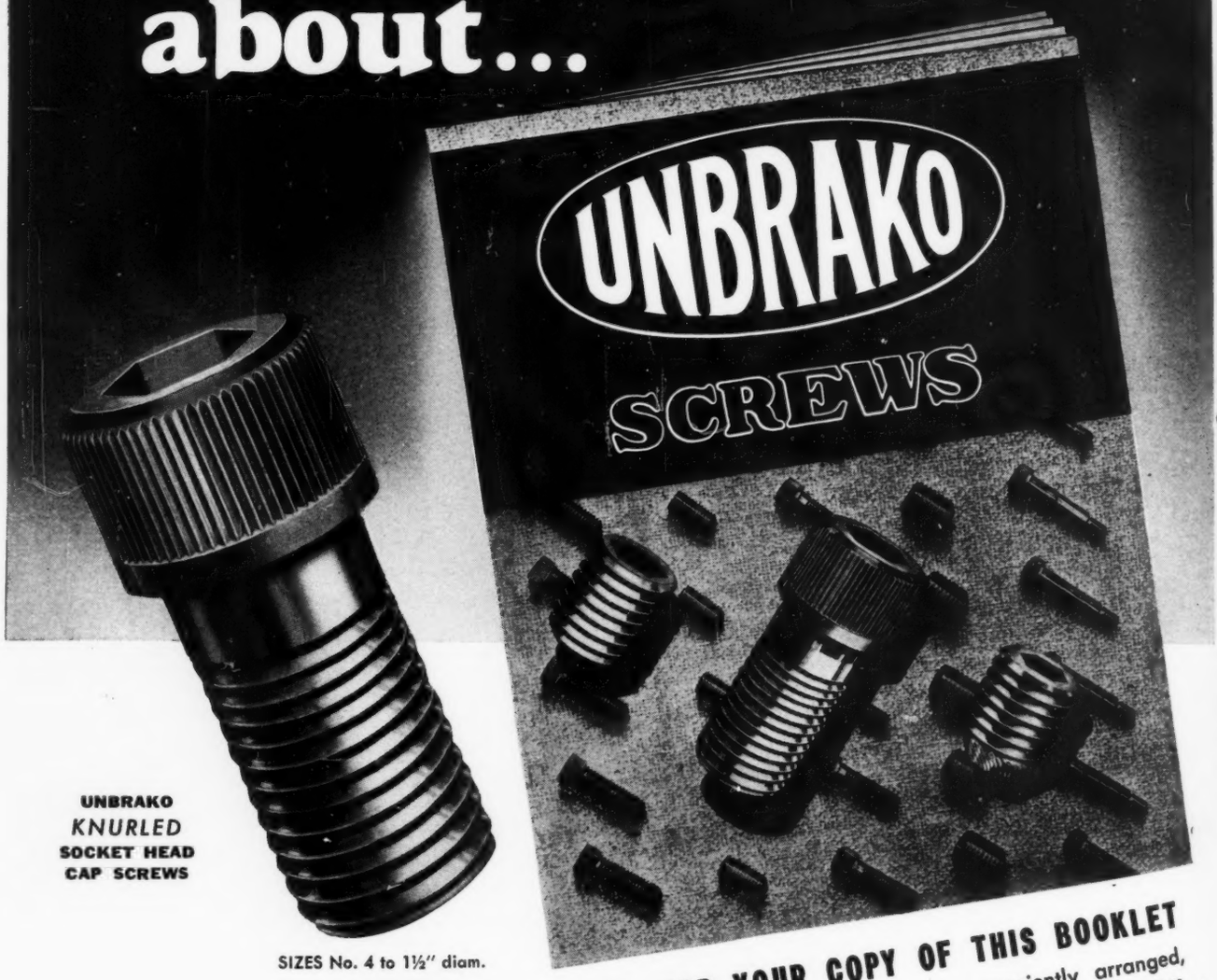
American Magnesium plants are producing quality castings, sheet, tubing, forgings and extruded shapes in tremendous quantities. Are you designing ahead for the day when these facilities will be available to you for your peacetime products? We'll gladly help. *Sales Agent:* Aluminum Company of America, 1703 Gulf Building, Pittsburgh, Pennsylvania.

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

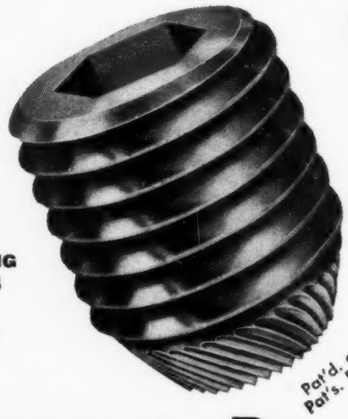
MAZLO MAGNESIUM PRODUCTS

Facts for Designers about...



UNBRAKO
KNURLED
SOCKET HEAD CAP SCREWS

SIZES No. 4 to 1½" diam.



UNBRAKO SELF LOCKING SET SCREWS WITH *KNURLED* POINTS

Pat'd. and Pat's. Pendg.

WRITE FOR YOUR COPY OF THIS BOOKLET

Gives complete detailed information, conveniently arranged, regarding "UNBRAKO" Knurled Socket Head Cap Screws, "UNBRAKO" Self-Locking Hollow Set Screws with the Knurled Points—and other famous "UNBRAKO" Screw Products. Lists sizes and prices, packing and weight schedules and a wealth of useful data about the "UNBRAKO" Line. Have this helpful booklet at hand for instant reference. Write for it today and we will send your copy to you.

KNURLING of Socket Screws originated with "UNBRAKO" years ago

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA. BOX 102

— BRANCHES —

BOSTON · DETROIT · INDIANAPOLIS · CHICAGO · ST. LOUIS · SAN FRANCISCO

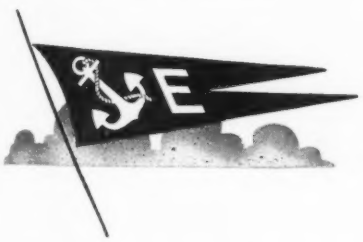
Ships are Forgings

And ships are a primary need of the day—fighting ships, troop transports, supply ships, tankers and other craft for use on inland waterways, in coastal service and in the inter-continental hauling of vast quantities of men and materials.

We're beating plow shares into swords 168 hours a week making rugged, stress resisting ship forgings for stem and stern, fighting tower and keel, and a thousand places in between.

While our facilities are crowded, we still want to serve more ship, tank, plane, gun, ordnance and machine tool builders. We'll stretch our production capacity, burn more midnight oil, do the impossible to assure rapid, intelligent handling of their forging needs.

It is our fervent desire to speed the day when free men can again travel the high seas, engage in free enterprise and follow the normal pursuits of industry.



Proudly we fly the Navy "E" flag awarded for excellence and proficiency in the production of Naval materiel.

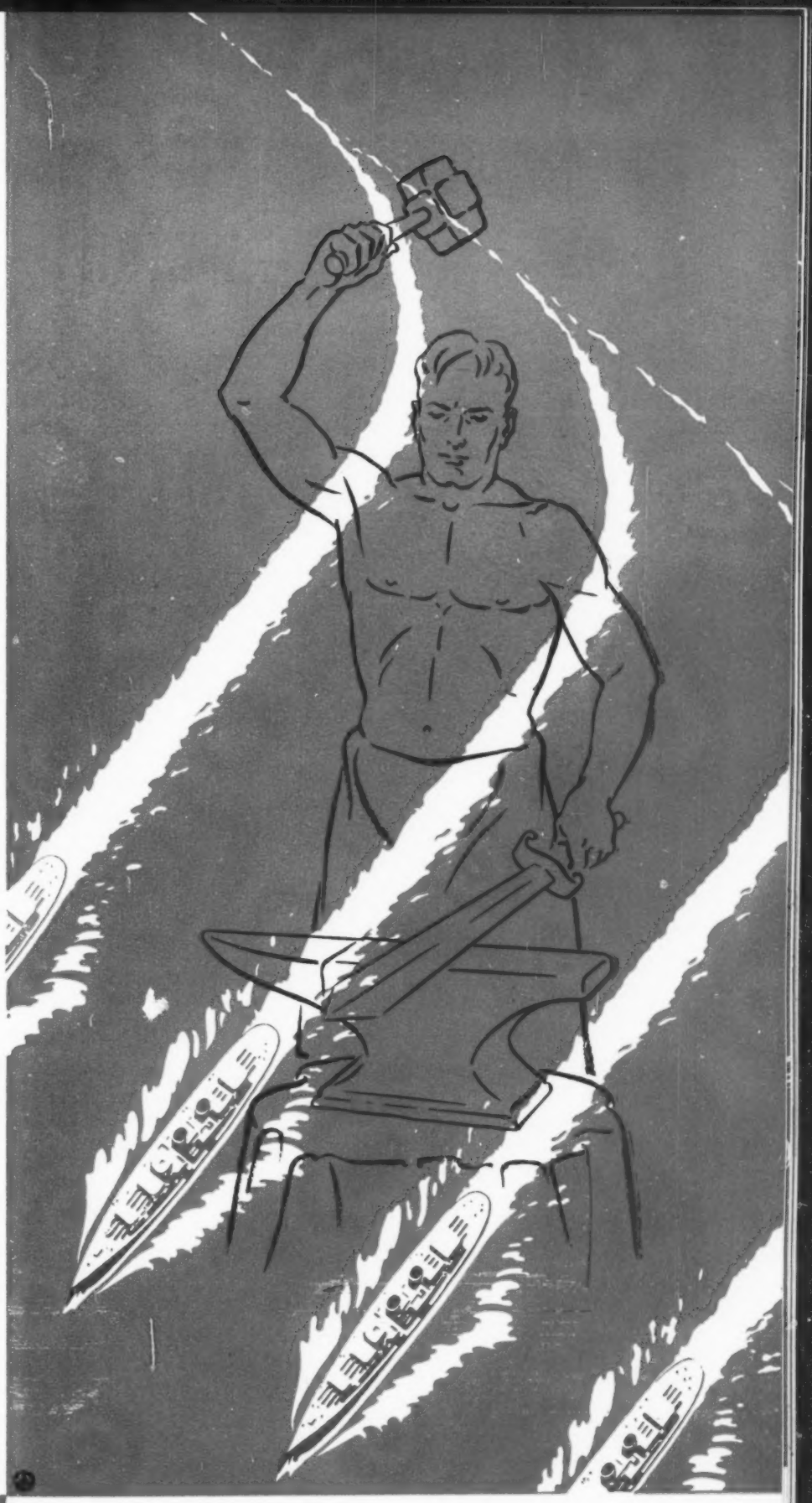
KROPP FORGE COMPANY

Makers of Drop, Upset and Hammer Forgings for Ships, Guns, Planes, Tanks, Ordnance and Machine Tools

World's Largest Job Forging Shop

5301 W. ROOSEVELT ROAD, CHICAGO, ILL.

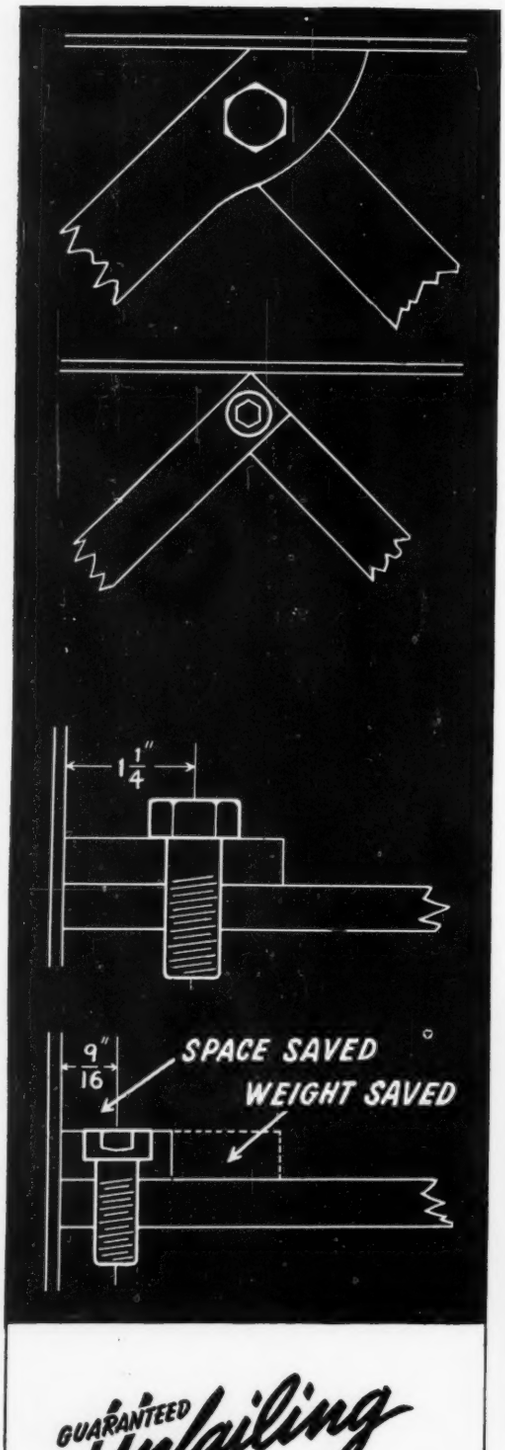
Representatives in Principal Cities



SERVING INDUSTRY SINCE 18 37 OVER 100 YEARS

KROPP FORGE CO.

KROPP



GUARANTEED *Unfailing* PERFORMANCE

Today, is the day to save WEIGHT—SPACE—TIME

by specifying

HOLO-KROME *fibro forged* SOCKET SCREWS

PRECISION MADE TO EXACTING STANDARDS BY THE HOLO-KROME PATENTED METHOD

Completely Cold Forged

FROM SOLID STOCK

NO DRILLING — MACHINING NOR EXTRUDING

WRITE FOR YOUR COPY OF COMPLETE SOCKET SCREW STANDARDS

THE HOLO-KROME SCREW CORP. HARTFORD, CONN., U. S. A.

Welded STEEL Machine BASES

IN compliance with the government's request, we are not privileged to disclose the nature of this massive *welded* base—nor its use. It is exhibited here solely for the purpose of focusing attention upon the character of work entrusted to Mahon and the high calibre of craftsmanship that goes into its fabrication. When you call on the experience and resources of the Mahon organization to build your machine bases and frames, you can be sure your blueprints will be followed with exacting attention to each detail and dimension, regardless of size, shape or design. With full allowance for the greater demands the war has brought about, this strict adherence to quality is largely responsible for the doubling and tripling of Mahon production within the past few months.

THE R. C. MAHON COMPANY

DETROIT CHICAGO

Manufacturers of Welded Machine Frames and Bases and Many Other Steel Products.

Due to our extensive facilities, we are equipped to handle a large volume of work. Send us your blueprints. Your job will be accurately analyzed and quotations promptly placed in your hands. Shipment assured at the earliest possible moment.

MAHON

FLEXIBLE! STRETCHABLE!...AND DURABLE!

Can VINYLITE Elastic Plastics help you solve a war-production problem?

Many essential products that formerly employed rubber can be served more efficiently and given longer life with VINYLITE Elastic Plastics. Flexible and stretchable like rubber, yet far superior to this vital material in many ways, VINYLITE Elastic Plastics are releasing rubber for those uses that it alone can serve.

VINYLITE Elastic Plastics are immune to many of the factors that cause rubber to deteriorate. They will not oxidize, and show no appreciable change even after prolonged aging. In abrasion resistance tests, certain types have proved superior to high-grade rubber compounds. Their tensile strength is higher than that of most rubber compounds. Under extreme climatic conditions, they do not become sticky or brittle —certain types retaining their flexibility even at –50 deg. F. Other types are non-flammable. Depending upon the formulation, unusual resistance to water, oils, and many corrosive chemicals can be obtained. Transparency is another unique feature impossible to obtain with rubber.

VINYLITE Elastic Plastics are available for war production needs in sheeting form and as compounds for molding, extrusion, and calendering. Sheeting is supplied in a wide range of transparent and opaque colors, in rolls of various widths and thicknesses. Compounds can be either injection or compression molded, extruded into continuous rods and tubes or into wire and cable coverings, or calendered directly onto cloth. For those industries which have the necessary processing equipment, such as the rubber industry, powdered VINYLITE Resins are available which can then be pigmented, blended with plasticizers, and formulated into flexible materials.

RUBBER-PROCESSING FACILITIES USABLE

Rubber manufacturers can realize important savings with VINYLITE Elastic Plastics. The handling of these materials is essentially the same as with rubber, and, with slight modifications, the same equipment can be used. However, no curing or vulcanizing is required, because VINYLITE Elastic Plastics come from the mold, extruding die, or calender mill as completed products.

If you are engaged in war production and seek flexible materials with the unusual resistance and durability of VINYLITE Elastic Plastics, we suggest that you enlist the full co-operation of our technical staff. Booklet P-4, "Vinylite Resins—Their Forms, Properties and Uses," describes these and other VINYLITE Plastics in detail.

Plastics Division

CARBIDE AND CARBON CHEMICALS CORPORATION

Unit of Union Carbide and Carbon Corporation

UCC

30 EAST 42ND STREET, NEW YORK, N.Y.

RIGID SHEETS • FLEXIBLE SHEETING AND FILM • ADHESIVES
MOLDING AND EXTRUSION COMPOUNDS • RESINS FOR SURFACE COATINGS

"VINYLITE" ELASTIC PLASTICS

bring many important properties to your products...

TOUGHNESS AND ABRASION RESISTANCE

In recent tests, a special VINYLITE Elastic Plastic was found to be several times more resistant to abrasion than high-grade rubber compound.

RESISTANCE TO FLAME

Insulation made of non-flammable types of VINYLITE Elastic Plastics is used widely on wire and cable in place of rubber and other dielectric materials.

NON-OXIDIZING AND NON-AGING

Oxygen bomb tests prove VINYLITE Elastic Plastics immune to oxidation. Thirty days' exposure to sunlight and weathering on coated cloth for Army raincoats also has no appreciable effect.

WATER AND CHEMICAL RESISTANCE

After 24 hours' immersion in water at 25 deg. C., absorption is only 0.20 per cent with certain types. Excellent resistance to oils, grease, and many corrosive chemicals can also be obtained.

COLOR AND TRANSPARENCY

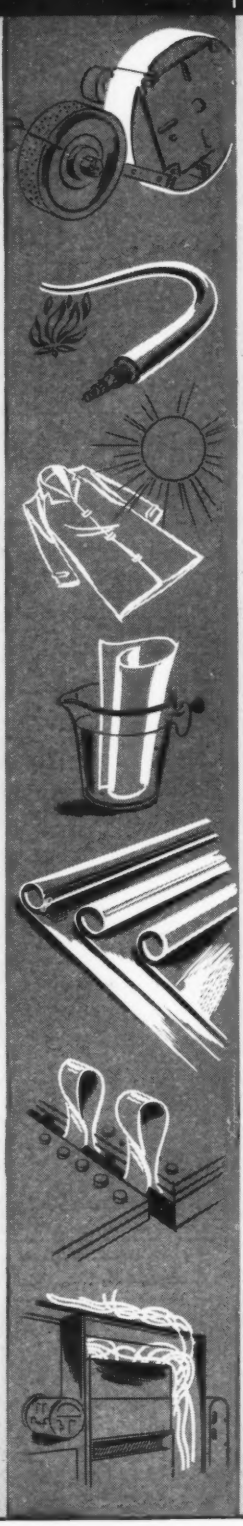
VINYLITE Resins can be pigmented to meet any color requirements. Unlike rubber, they can be formulated into transparent as well as opaque forms.

FLEXIBILITY AND STRETCHABILITY

Certain types withstand 3,000,000 cycles in a mechanical flexing tester. They may be elongated 300 per cent at room temperature, but will return to original length without "snapback."

ELECTRICAL INSULATION

Dielectric strength, in 0.025-in. thickness at 25 deg. C., ranges from 900 to 1,100 volts per mil, and 300 to 330 volts per mil in 0.125-in. thickness.



meet many different fabrication and application needs...

INJECTION MOLDING

Unlike rubber, complete products can be formed from VINYLITE Elastic Plastics by high-speed injection molding. This process brings marked economies on long runs.

COMPRESSION MOLDING

In many instances, VINYLITE Elastic Plastics can be compression molded in existing rubber molds, with minor modifications. Parts come from the mold ready for use — curing and vulcanization are avoided.

SCREW EXTRUSION

VINYLITE Elastic Plastics can be fabricated in standard types of screw extruders into continuous tubes, rods, and insulation coverings for wires and cables.

SPREADER COATINGS

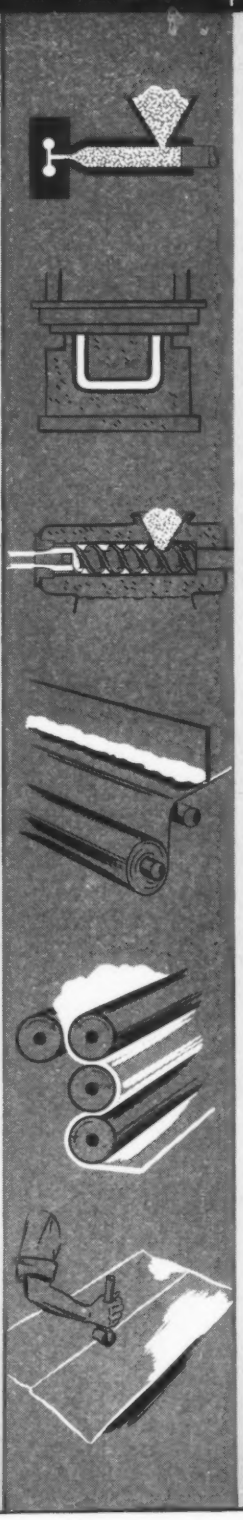
Dissolved in suitable solvents, VINYLITE Elastic Plastics can be applied to cloth on standard spreader-coating equipment.

CALENDERING

Durable, waterproof coatings on cloth, up to .030 inches thick, can be applied by standard calender mills used for rubber.

FABRICATING

Flexible sheeting and coated cloth can be either cemented or heat-sealed. Embossing is used to obtain various surface effects.



make possible many advanced wartime products...

INFLATABLE EQUIPMENT

Inflatable equipment, waterproofed by coating one or both sides of the cloth with VINYLITE Elastic Plastics is more durable than similar equipment made from rubber-coated cloth.

AIRCRAFT PARTS

Flexible even at —50 deg. F., VINYLITE Elastic Plastics are used for transparent aircraft wiring conduits, weather-resistant windshield wiper blades, floor mats, gromets, and wire terminal insulators.

RAINCOATS AND PAULINS

Army raincoats, tenting, and equipment paulins coated with VINYLITE Elastic Plastics retain their water resistance — without becoming brittle when cold, or sticky when hot.

UPHOLSTERY FOR HARD SERVICE

VINYLITE Elastic Plastics are used for upholstering seats in tanks and planes where they are far superior to rubber and artificial leathers in moisture resistance, toughness, and flexing life.

ELASTIC WIRE AND CABLE INSULATION

Durable insulation for vital electric wires and cables is made from VINYLITE Elastic Plastics. Non-flammable and abrasion-resistant, they eliminate additional protective wrappings.

CHEMICALPROOF PRODUCTS

Highly resistant to chemical fumes and liquids, VINYLITE Elastic Plastics provide flexible frames for gas masks, coatings for electroplating equipment, and durable tops for storage batteries.

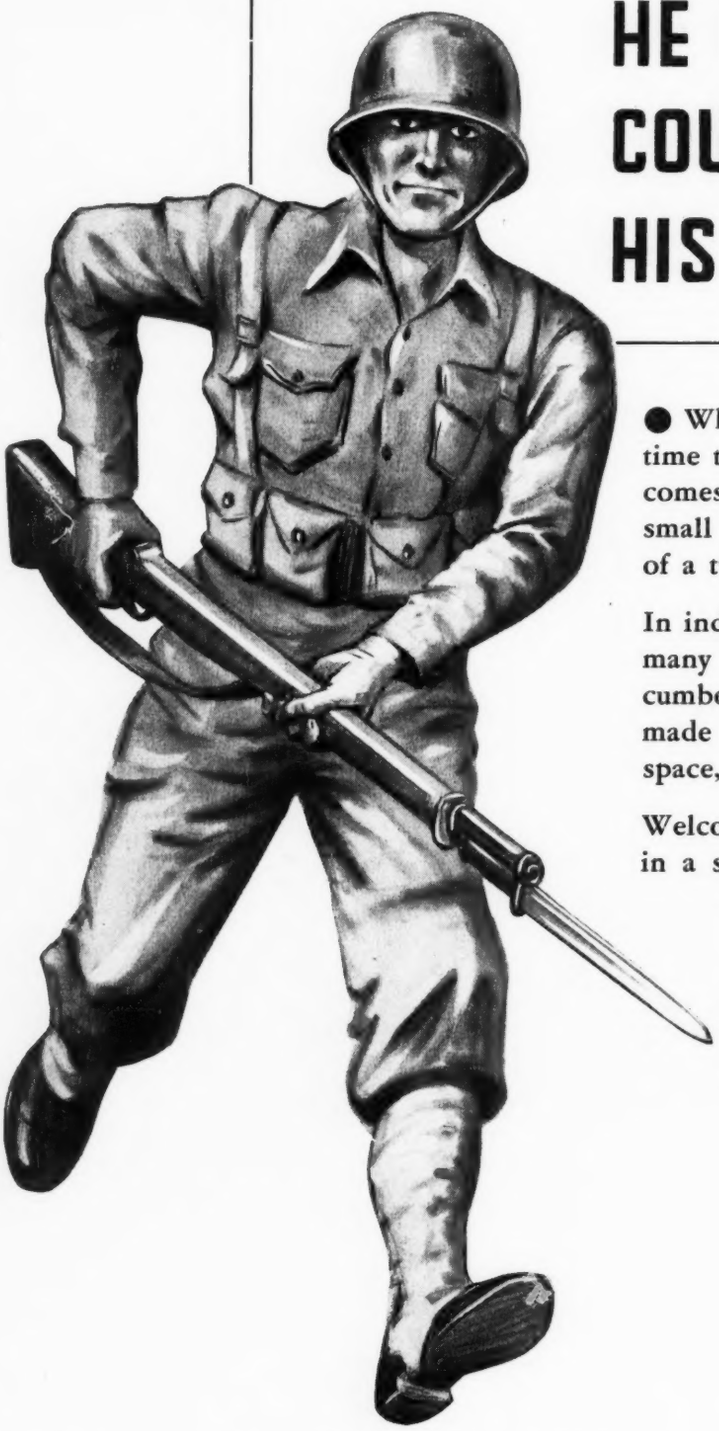
Vinylite*

TRADE MARK

PLASTICS

**The word "Vinylite" is a registered trade-mark of Carbide and Carbon Chemicals Corporation.*

HE CARRIES A NINE COURSE DINNER IN HIS SHIRT POCKET

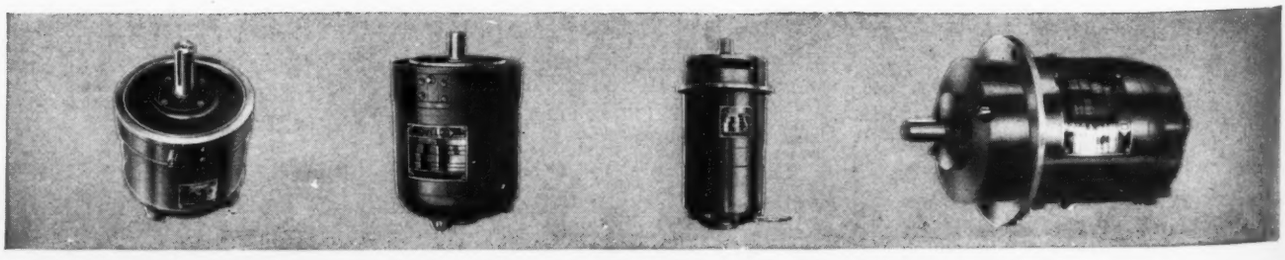


● When the action gets fast and there is no time to sit down and relax, fighting energy comes in concentrated form. A couple of small vitamin tablets give our boys the zip of a two-inch steak with all the trimmings.

In industry the torque motor has revitalized many types of machines once powered by cumbersome peacetime models that were made without regard to critical materials, space, and 24-hour working days.

Welco Torque Motors embody terrific power in a small frame and are mountable in any position. Simple construction means trouble-free operation. May be stalled and quickly reversed—power on the spot where the power is needed. For a specific torque motor for a specific job, look to Welco.

TORQUE
WELCO
MOTORS

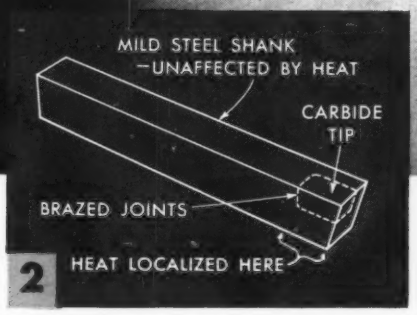


The B. A. WESCHE ELECTRIC CO., 1820 Vine St., Cincinnati, Ohio

BRAZED by TOCCO in 20 SECONDS!

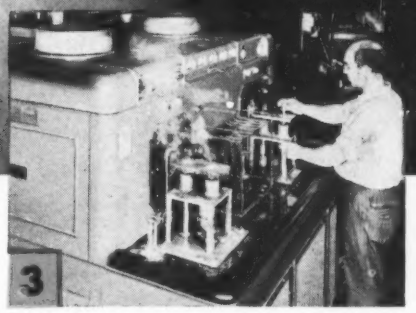
1

Adapters are being silver-soldered in 4.2" mortar shells at the rate of 20 seconds per shell by TOCCO Induction Heating. The base also is silver soldered by TOCCO. Rapid and localized heating maintains the original physical properties of the shell.



2

Another TOCCO-brazing application. Carbide tips are brazed to mild steel tool shanks by TOCCO Induction Heating as shown. Rapid heat, confined to brazed zone, produces tight, uniform brazes.



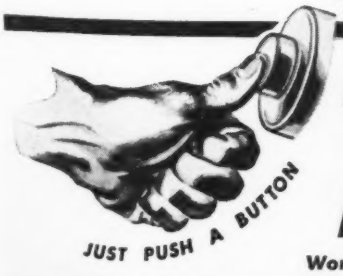
3

TOCCO Jr. machines are processing a wide variety of war materials such as burster tubes, shown above. TOCCO machines can be used for hardening, brazing, annealing or heating for forging or forming... war or peace-time products... by changing only the work fixture.

Full details in "The TOCCO Process" booklet. Free on request.

THE OHIO CRANKSHAFT COMPANY

Cleveland, Ohio



TOCCO

World's Fastest, Most Accurate Heat-Treating Process

HARDENING
ANNEALING
BRAZING
HEATING for forming and forging

Metal-Powder Products *for War Production*

The Amplex Division of Chrysler Corporation, which has for many years been manufacturing Oilite self-lubricating bearings, is now also in production on solid bronze and iron parts made from powdered metals.

Two Chrysler products are Stressite and Damascite, which can be used instead of castings, stampings, forgings or bar stock.

Since these parts can be made in many forms, machining is almost entirely eliminated with resultant savings in cost of manufacturing and scrap.

For example, on the instrument part made of Stressite bronze (illustrated above), two hours of machining alone used to be necessary. When the part was made from powdered metal, only twenty seconds were required to manufacture the product.

Our engineers are at your service.

CHRYSLER CORPORATION
(AMPLEX DIVISION)
DETROIT, MICHIGAN

Since the First Shot was Fired WE'VE BEEN *"Shooting the Works"*

Back in the days of peacetime production, it was all right with us if the only thing you knew about Delco Products was that we built sturdy, dependable Delco industrial motors to drive your machine tools.

We're still building these motors, and your good opinion of them is still mighty important to us. But you should also know at this time that urgent war assignments have been entrusted to Delco Products, and that it is our responsibility as an American organization to put them first. We have applied our engineering experience and manufacturing "know-how" in full force to the design and manufacture of aircraft electric motors that meet latest military requirements . . . to the production of armament materials . . . to the building of electrical equipment for the Navy . . . and to other war assignments not for publication. Like you, we are "shooting the works" on war production until the shooting is over; this is, and must continue to be, our No. 1 job.

DELCO MOTORS

DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS DAYTON, OHIO

WALKER-TURNER FLEXIBLE SHAFTING

...meets war's hardest tests!

In aircraft and other mechanical weapons — where requirements are unusually severe — Walker-Turner Flexible Shafting has thoroughly demonstrated exceptionally high quality of design and materials. As one of the largest manufacturers of flexible shafting for industry, Walker-Turner has gained wide experience in design, production and application of flexible shafting for remote control and power transmission.

Although it is one of the busiest departments of this Company, we are always glad to help other concerns who may wish to learn more regarding the possibility of simplifying design through the use of flexible shafting. Walker-Turner Flexible Shafting is available today in products used for war purposes, in a wide range of sizes and specifications.

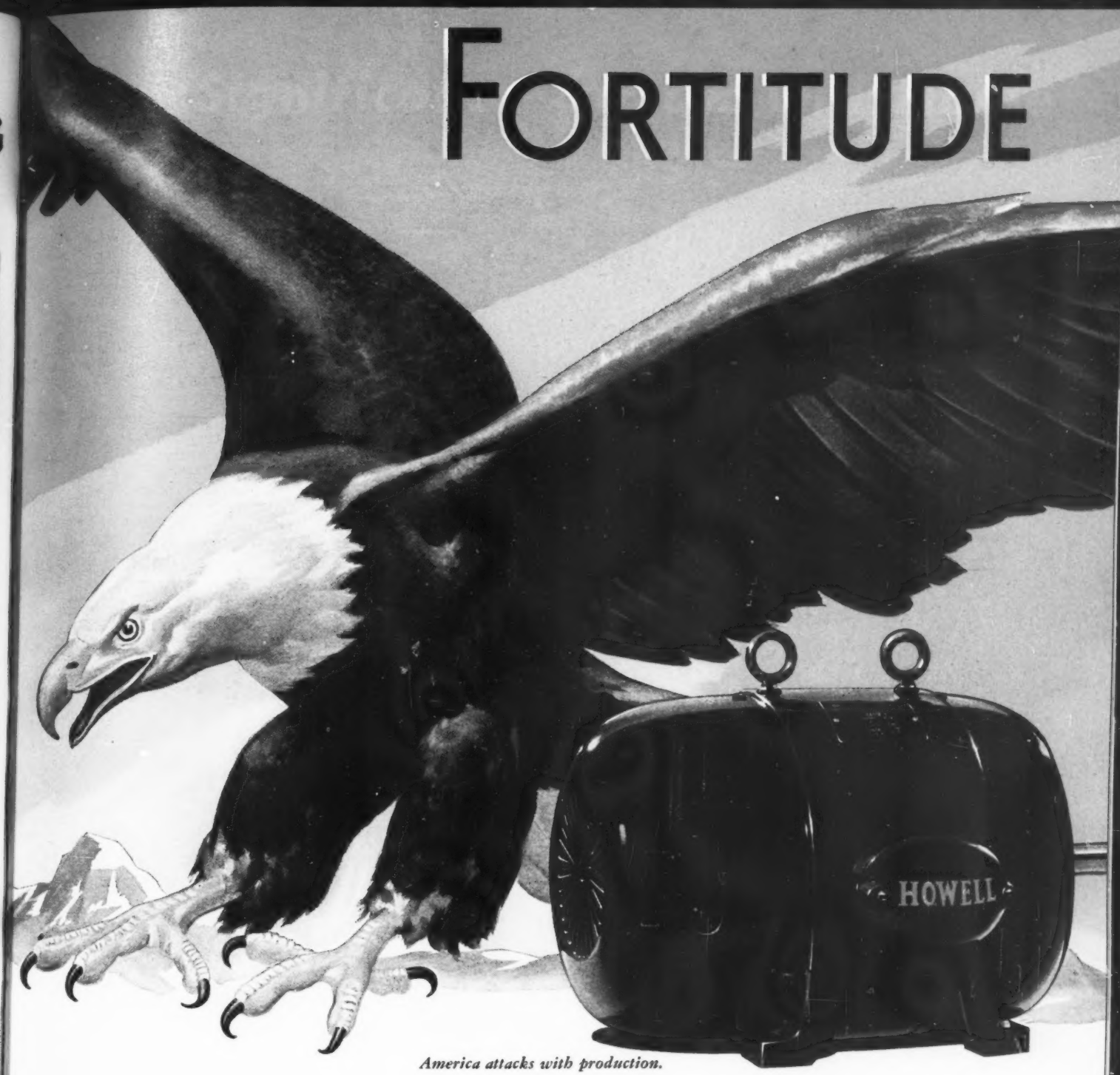
WALKER-TURNER COMPANY, INC.
23122 Berckman Street Plainfield. N. J.

walker-turner
COMPANY, INC.
PLAINFIELD, N.J.
U.S.A.

FLEXIBLE SHAFTING

FOR REMOTE CONTROL AND POWER TRANSMISSION

FORTITUDE



America attacks with production.

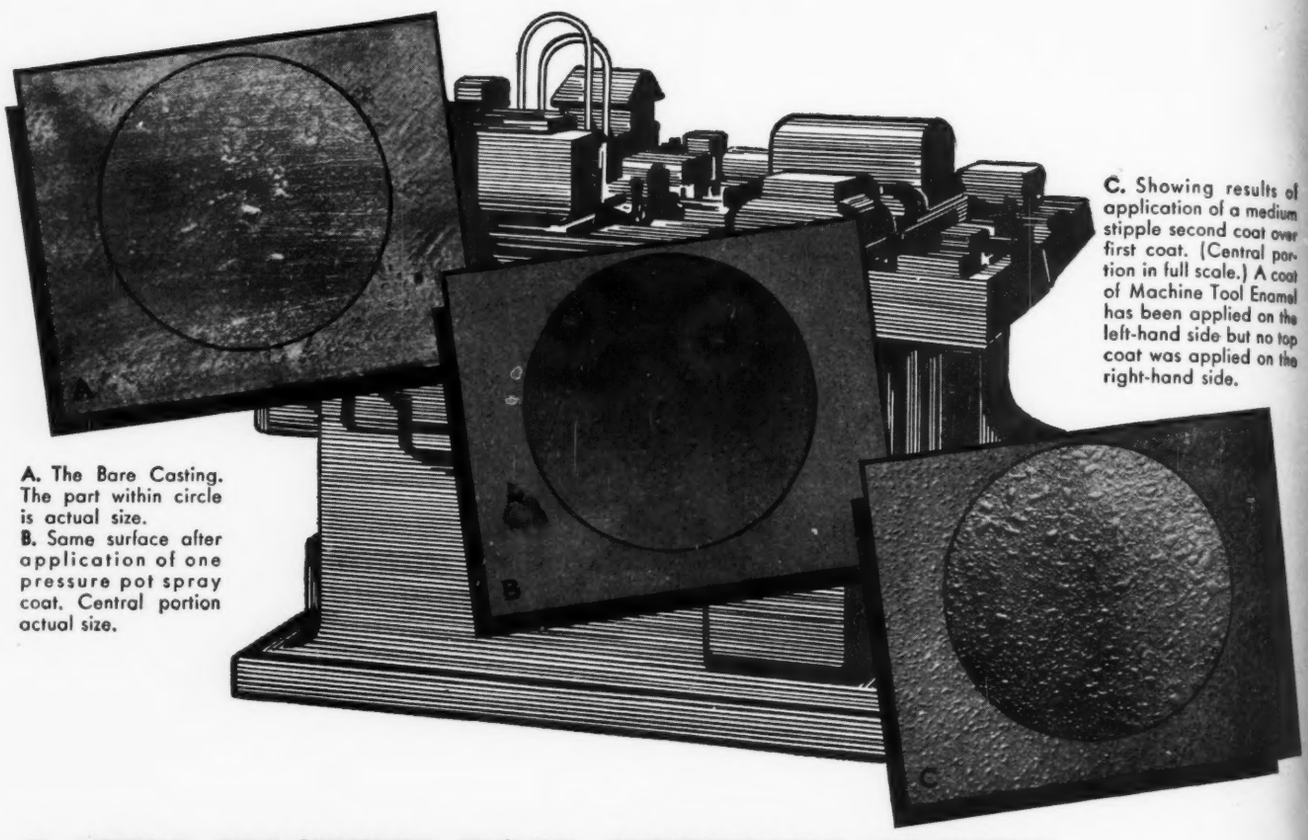
WE CAN be thankful, these days, for American Fortitude . . . The fortitude of our armed forces will bring victory on the fighting fronts . . . The fortitude of our workmen and manufacturers will overcome the plotting, planning, and more-than-eight-year production start on the part of the Axis; will enable us to out-produce the world in bombs, bullets, planes, tanks, ships . . . Howell Electric Motors are playing an important part in all of these vital war industries . . . They are holding their old friends, winning new friends, with their fortitude as exemplified by their ability to outperform and out-last on the production front. Howell Electric Motors are *better built* by an organization that's all-out for victory — by men and women who cherish the American ideals of liberty and free enterprise and are willing to sacrifice everything to protect them.

★ ★ ★ ★

The **HOWELL IDEA**
in Electric Motors
precision-built

★ ★ ★ ★

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN · *Manufacturers of Quality Motors Since 1915*



A. The Bare Casting. The part within circle is actual size.
B. Same surface after application of one pressure pot spray coat. Central portion actual size.

C. Showing results of application of a medium stipple second coat over first coat. (Central portion in full scale.) A coat of Machine Tool Enamel has been applied on the left-hand side but no top coat was applied on the right-hand side.

A NEW MACHINE TOOL FINISHING SYSTEM FOR PRESENT HOUR NEEDS

Here's a NEW machine tool finishing system which is entirely consistent with WPB Limitation Order L-108. Designers, finishers and customers are enthusiastically endorsing it wherever it is used.

It's a three coat system which produces a stipple effect, minimizing those rough spots found in every casting by blending them with the rough finish.

It can also be used for a smooth finish where desired since it gives a maximum of filling and smoothness to castings consistent with a complete spray job.

Here are the high lights of the NEW EGYPTIAN Machine Tool Finishing System.

1. **FAST, AIR DRYING Lacquer materials.**
2. **No Primer required.**
3. **Oil and alkali resistant.**
4. **Applied by spray or brush.**
5. **Finish levels or rounds out as it dries.**
6. **Gives stipple effect in two coats. A coat of EGYPTIAN Machine Tool Enamel completes the job.**
7. **Any make of Stipple equipment may be used. Spray equipment manufacturers can furnish suitable accessories to go with equipment for proper application.**

Ask us for detailed information about the new EGYPTIAN Machine Tool Finishing System . . . or better still let us ship you a trial order at drum prices.

Send for this new Gov't "Spec" Book. Contains information concerning specifications for the more important finishes used on equipment for all branches of the Service. Just ask for "Spec" Book MD12.

THE EGYPTIAN LACQUER MANUFACTURING CO.
ROCKEFELLER CENTER—NEW YORK, N. Y.

EGYPTIAN
Superior FINISHES

New Significance *for an* Old Name

HOWARD has long been a dominant name in the nonferrous castings field. Howard castings have been widely used in many well known machines and equipments.

Today, the name Howard takes on a new significance. Three plants combined — an aluminum foundry, a bronze foundry and a magnesium foundry — provide the largest nonferrous jobbing facilities in the United States. Our new magnesium foundry has a capacity alone of over 500,000 pounds of castings per month.

Naturally, America's war industries have turned to this dependable source of nonferrous castings; and all three plants are supplying the needs of makers of planes, guns, tanks, ships, military vehicles and essential machines.

Today, Howard castings are available only to those with adequate priority ratings, but war uses of nonferrous castings are pointing the way to new and important peace-time applications, especially in the field of magnesium. Accordingly, Howard will be in a position to render a broader service to industry after the war.

Howard Foundry Company
4900 Bloomingdale Road Chicago

HOWARD

ALUMINUM · BRASS · BRONZE · MAGNESIUM

CASTINGS

"What's the big excitement over this new type brake, Bill?"

"Well, Boss, the extraordinary torque of the Magdraulic Electric Brake is developed within the brake itself. That means we can do without auxiliary booster equipment."

Don't expect "E" performance with slipping brakes!

Slipping brakes are saboteurs of production! They pile up man-hour and material losses at terrific cost. Why carry over braking inefficiencies into new machine designs? Magdraulic Electric Brakes can give your new models peak efficiency with precision braking.

ELIMINATE AUXILIARY BRAKE BOOSTERS

The extraordinary torque developed by the Magdraulic Brake originates within the brake itself. The performance story below is typical of the tough braking jobs Magdraulics can handle better. Note the self-contained, compact and streamlined appearance of the Magdraulic Electric Brake as compared to the solenoid-type mechanical brake.

The operating principle and design of Magdraulic Electric Brakes are simple. They are easy to adapt, easy to service.

Before you freeze designs consult with our engineers on how to adapt your designs to accommodate a Magdraulic Electric Brake for industrial machinery.

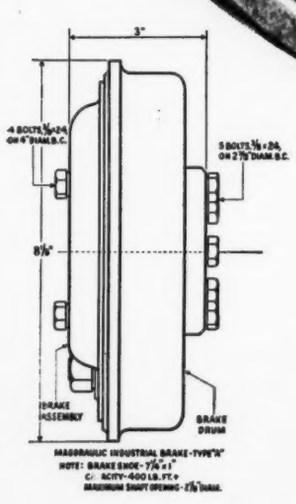
48% INCREASE IN PRODUCTION!

Here's what one new Magdraulic user writes: "After a 30 day test we were convinced of the superior efficiency of the Magdraulic Electric Brakes. Since the changeover from a solenoid-type brake our all-over production has increased 48%, material spoilage was cut 60%, man-hour waste was cut 90%, we practically doubled our production without adding a single new machine."

For vehicles, too! If you make cars, trucks, trailer units or other types of automotive equipment you'll be interested in the performance of certain heavy duty mobile war equipment equipped with Magdraulic Electric Brakes.

Write at once for Data Book, to

EMPIRE ELECTRIC BRAKE CO., NEWARK, N. J.



MAGDRAULIC INDUSTRIAL BRAKE - TYPE "R"
NOTE: BRAKE SHOE - 7/16 x 1"
C: ACITY - 400 LB. FT.
MAXIMUM SHAFT OPENING - 2⅜" DIAM.

MAGDRAULIC
ELECTRIC BRAKES
FOR AUTOMOTIVE VEHICLES AND INDUSTRIAL MACHINERY

This MAGDRAULIC Electric Brake on injection plastic molding machine replaced the solenoid - type brake (left). Eliminated back-slipping against 50,000 lbs. per sq. inch pressure. Production up 48%. All new machines to be Magdraulic-braked.

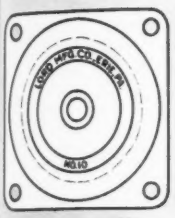
Designing . . . FOR USE OF LORD BONDED RUBBER MOUNTINGS

Standard Plate Form Mountings

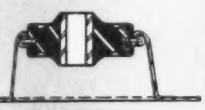
THE choice of the proper flexible mountings to utilize in any given installation usually depends on static loading and the need for both translational and lateral flexibility. To fit these several conditions Lord produces a complete line of Plate Form Mountings which have load ratings ranging from a few ounces to 300 lbs., in four standard dimensional sizes. They are compact, light weight units, designed to isolate harmful vibration and to minimize all solidly-conducted noise.

Lord Plate Form Mountings are easy to install, as no intricate layout, special tooling or close machining is necessary. Simply provide holes for attachment, clearance for the rubber body, and the necessary small bolts for fastening the assembly to the center sleeve of the mounting. The line drawings and photographs show the several different shapes in which these mountings are made and a few typical methods of installation.

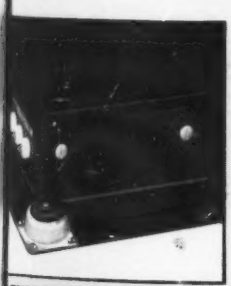
Due to the Lord method of bonding rubber to metal, the rubber, when loaded on main axis, is stressed in free shear. This design for free shear softness in the direction of the disturbing forces, results in an exceptional reduction in the natural frequency of the mounted system. This fundamental principle is incorporated in all the types of shear-stressed rubber mountings produced by Lord, all of which are fully described in our Engineering Bulletins 103 and 104 on the subject of "Vibration Control". Write for your free copy or call in a Lord Vibration Engineer for consultation on your design problems. There is no obligation.



HOLDER TYPE

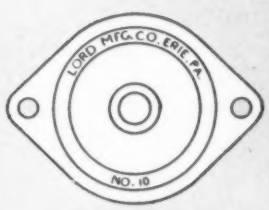

CROSS SECTION

INVERTED HOLDER TYPE


TYPICAL INSTALLATION

SQUARE SHAPE

ROUND SHAPE



DIAMOND SHAPE

CROSS SECTION

TYPICAL INSTALLATION

LORD MOUNTINGS

PROLONG EQUIPMENT LIFE by isolating vibration, which reduces metal fatigue, thereby preventing subsequent failure.

INCREASE PRODUCTION by eliminating the necessity for close machining and precision alignment.

SAVE VITAL MATERIAL by reducing equipment weight; heavy inertia masses of machinery bases can be eliminated.

INCREASE PERSONNEL EFFICIENCY by eliminating nerve wearing noise and vibration, translated through solid conduction.

LOWER MAINTENANCE COSTS by protecting equipment against sudden load shocks and stresses, thereby minimizing repair and replacement operations.

ORIGINATORS OF SHEAR TYPE BONDED RUBBER MOUNTINGS

LORD MANUFACTURING COMPANY . . . ERIE, PA.

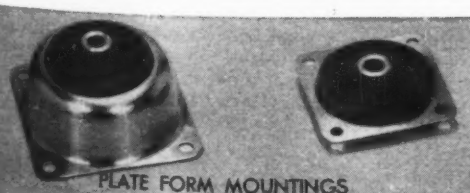
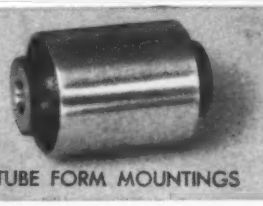


PLATE FORM MOUNTINGS

LORD
BONDED RUBBER
SHEAR TYPE
VIBRATION
MOUNTINGS


TUBE FORM MOUNTINGS

FRACTIONAL H. P.
FLEXIBLE COUPLINGS

SALES REPRESENTATIVES . . . NEW YORK, 280 Madison Ave. . . . CHICAGO, 520 N. Michigan Ave. . . . BURBANK, CAL., 245 E. Olive Ave.

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

A message to men who sa

Characteristics of Cook "*Spring-Life*" Bellows

Enumerated and discussed below are some of the characteristics and engineering advantages of the Cook "Spring-Life" bellows construction. They are as follows:

Dependability

From exhaustive tests conducted over a period of years —tests far in excess of normal usage—we can almost guarantee the dependability of "Spring-Life" construction. By employing metals which are virtually fatigueless and keeping the flexing motion well within the elastic limits of these metals, the expected service life of Cook "Spring-Life" Bellows is almost unlimited.

Leak-proof Service

The combination of lock seams, our method of soldering, the temper of the metals employed, insure leak-proof service even where operating pressures seem high enough to be a likely source of trouble.

Resistance to Corrosion

Conscious of the fact that many bellows are employed in applications which have to meet corrosive conditions, we supply Cook "Spring-Life" Bellows of tinned phosphor bronze, high-carbon steel, and Monel metal. Even silver plated bronze has been employed to meet special requirements. For bellows to be used under corrosive conditions, we use pure tin where the elimination of lead as the soldering medium seems to be desirable.

Sensitive Low-pressure Response

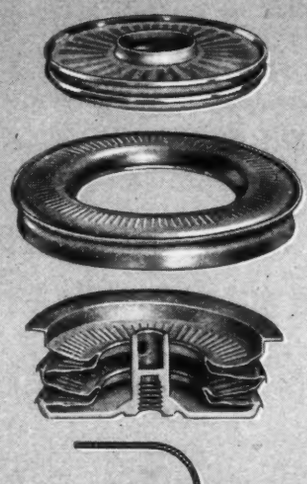
Sensitive dimensional response to small increments of pressure is a matter of the degree of flexibility within the bellows units. Flexibility varies directly with the number of flanges. Affecting the flexibility of each diaphragm are the factors of thickness of metal and width of flange. The width of the flange is subject to variation within a considerable range during manufacture. For example, our 2¾" bellows is available with inside diameters of ¾", 1", and 1¼". The travel per flange for each pound of variation in pressure per square inch is, respectively, .0105", .0077", and .0050". These figures are the measure of flexibility and show the required flexibility can be obtained by varying the width of the flange and is not dependent upon the use of metal so thin as to invite rupture.

Uniform Pressure-movement Ratio

Because Cook "Spring-Life" Bellows are made of tempered metals and the flange width can be altered, they offer the user more travel or displacement than any other type of bellows. In ordinary bellows, the pressure-movement ratio will remain uniform within the elastic limit of the metal. In Cook "Spring-Life" Bellows these limits extend much further above and below the "no-load" position than in other types. Therefore, because the pressure-movement ratio remains constant and the ability to return to the same "no-load" position remains unimpaired almost indefinitely, the Cook "Spring-Life" Bellows responds under load like a true spring. Thus, Cook "Spring-Life" Bellows offer unusual strength and ruggedness even with highly sensitive dimensional response.

Upper—4⅝" Low Pressure Bellows

Right—1¾" High Pressure Bellows Showing End Plate



This is the "*Spring-Li*

The "Spring-Life" principle employs a method of construction [illegible] diaphragms or flanges are joined alternately at their inner [illegible] peripheries. Each flange, as shown, is a simple, patented form [illegible] ized by a flat section with radial corrugations and cupped [illegible] outside edges as illustrated.

Close control of the temper of the metal is easily maintained [illegible] fabrication and the use of such tempered metals as phosphor [illegible] steel, and Monel metal presents no problems.

The radial corrugations in each flat section provide greater [illegible] greater resiliency as desired, add materially to the life of the [illegible] and permit closer control of the flexibility of each diaphragm.

Another important advantage inherent in this design is the [illegible] flexibility which can be obtained by changing the inside diameter [illegible] the outside diameter remains constant. Thus, in a bellows unit [illegible] given number of diaphragms and a fixed outside diameter, the [illegible] flexibility desired can be secured by selecting the proper inside [illegible]

When the diaphragms are assembled into a bellows, flexure takes [illegible] both the inside and outside curved section when pressure is applied [illegible] low pressure, the movement is approximately equal at both points. [illegible] heavy stress, the greatest portion of the movement takes place in the [illegible] curved section, as shown in the cut-away view to the left. When [illegible]

sa 4 Bellows Won't Do!"

OOK "Spring-life" BELLOWS offer many surprising dvantages for service beyond the scope of ordinary bellows

design, the development, and construction of the Cook ring-Life" Bellows is a direct result of this company's ility to find a bellows on the open market that would t our own requirements.

r racking laboratory tests, after long and proved serv- n our own production, after superlative performance in most severe types of service—we are now ready to ocate, engineer and supply the Cook "Spring-Life" ows to those segments of industry which require a dard of performance in the larger sizes, not ordinarily ilable in bellows.

The Cook "Spring-Life" Bellows is different in principle, different in design, different in materials employed, different in the type of service it will render.

These bellows are not "crushed" together—they are formed and assembled. The patented design is such that its serviceability is limited only by the fatigue point of the metal employed. These metals are tempered metals of low ductility and, because of this, they withstand terrific shocks without losing their "Spring-Life". Consequently, they can be built in much larger diameters and lengths than one piece bellows made of highly ductile metals with a low fatigue point.

Here Is the Toughest Job Any Bellows Can Be Asked To Do

Here is a diagrammatic view of the Cook "Spring-Life" Bellows as used in a Water Hammer Arrester. No ordinary bellows could withstand the terrific shocks, the violent and sudden compressions which take place in this service.

In this application, the Cook "Spring-Life" Bellows "takes it," eliminating the noise and cushioning wear and tear on the system. No ordinary one piece bellows —made of highly ductile metal with a low fatigue point—could take this punishment and stand up.

Here Are Two Widely Different Applications

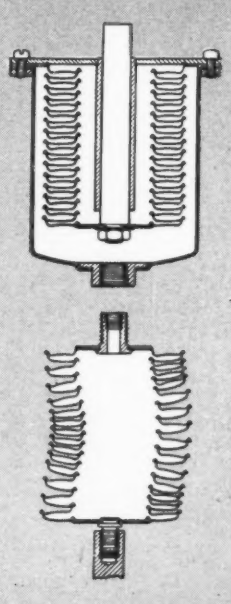
Cook "Spring-Life" Bellows, as illustrated at the right, are used in automatic temperature and altitude control units for governing proper air and gas mixtures on some of the Army's finest aircraft. Precision, dependable performance with straight line operation, and the durability to withstand engine shock and vibration are the requirements of the bellows used in this application. Failure of this part to function correctly would lead to disastrous results, yet Cook "Spring-Life" Bellows are "taking it," and giving all of the desired performance in active duty with a high factor of safety.

Cook "Spring-Life" Bellows complete with tank assemblies, such as illustrated at the right, have been supplied to leading power companies for use as oil expansion reservoirs for rugged, dependable duty as required on high voltage transformer banks. Interruption of service due to over-heated or burned-out transformers is eliminated because of the correct and sturdy performance of Cook "Spring-Life" Bellows in expansion tanks. These tanks are subjected to severe pressures and weather conditions at all times.

inciple . . .

a Cook "Spring-Life" Bellows—which is seldom ways found in the outer curved section, not int. Therefore, this eliminates any doubt as dependability of the lock-seamed and d joints, as shown to the right; or of there weak point in the bellows which might ap- Le the case without sufficient study of the tion of the bellows as a whole. In construct- joint, solder is flowed into an open groove. cedure avoids a sweated joint and elimi- ir bubbles.

y, because of the "Spring-Life" construction bellows, it is obvious that its action is like a long spring under tension. As a conse- the action of the bellows may be compared g spring under compression. Under these s the bellows have a tendency to bulge side and throw stress on some diaphragms eater than others. Therefore, when pressure ed to the outside, it is necessary to mount ows in a cup as shown.



How can the Cook "Spring-Life" Bellows help me?

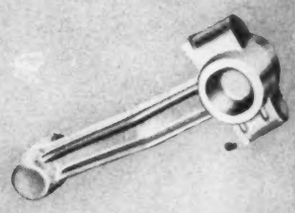
Here is a new book just off the press that contains the complete story of the Cook "Spring-Life" idea, its history, its advantages, its applications, and complete data for specifying and ordering Cook "Spring-Life" Bellows. Send for as many copies as your engineering department may require.

COOK ELECTRIC COMPANY

2700 SOUTHPORT AVE., CHICAGO, ILL.

600
FORGEABLE BEARING ALLOY
Conserves Tin!
. . . AND HAS SUPERLATIVE BEARING PROPERTIES

CONNECTING RODS



GEARS

SPINDLES

GEAR BLANKS • BUSHINGS • BEARING PINS • DRAWN RODS

WORM GEARS

DRIVE SHAFTS

PROPELLER SHAFTS

VALVE STEMS

● 600 Bearing Alloy is the solution to many difficult bearing problems. It is for the "hard-to-crack" applications. It can be drawn or forged and readily fabricated in a great variety of sizes and shapes. It is approximately three times stronger than the best cast bearing bronze, and develops a lower temperature under heavier loads and higher speeds. Extreme pressure lubricants do not corrode it.

600 Metal is a true bearing metal and—an entirely different one. It has a structure made up of two types of crystals—soft and hard. In this alloy, the hard crystals are elastically and very uniformly embedded in a matrix of soft crystals. The hard crystals absorb the pressure in the bearing, diminish the friction, and cause a better distribution of lubricating oil between bearing surfaces.

600 is a superior material for high speeds at light loads or for slower speeds at heavy loads running against hardened, well finished shafts. Because of its own hardness, it is not suited for running against soft steel at heavy loads.

600 has been successfully used for the past 14 years in many thousands of auto and truck transmissions, for pump rods, propeller shafts and power boats; in worm wheels, small and large, in cams and cam rollers, and for thrust collars, seal rings and a thousand other uses.

The need for conserving tin and copper at this critical period is an added reason for its adoption and increased use.

If you have a particular problem, our engineers and metallurgists will be glad to place their services at your disposal or extend their advise to assisting you to a solution. Write for a complete illustrated treatise.

MUELLER BRASS CO.

PORT HURON • • • MICHIGAN

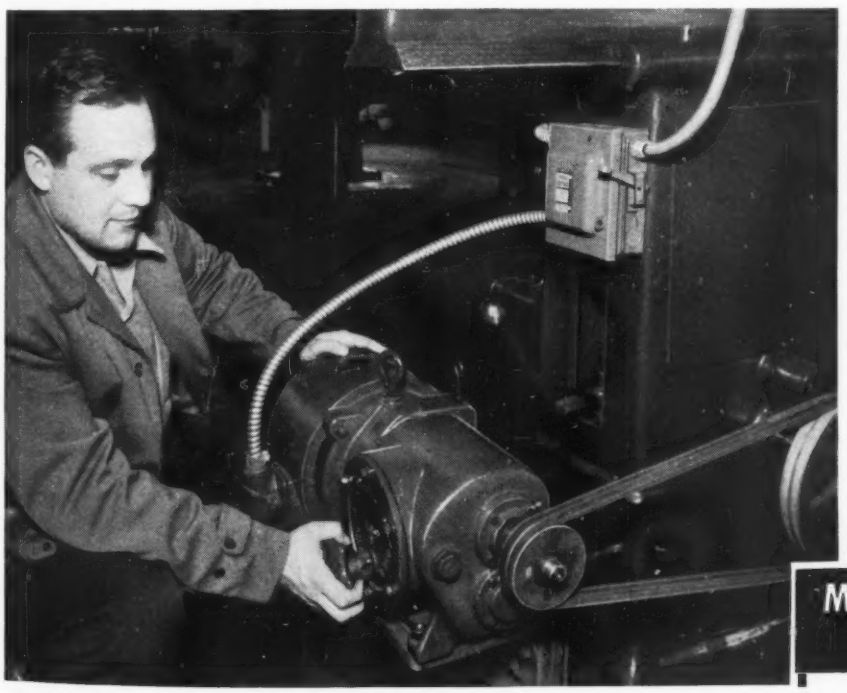
YOU BUILD THE *Machines*.. LET US BUILD THE *Drives!*

YOU'LL SAVE DESIGNING AND PRODUCTION TIME . . . AND INCREASE OUTPUT

If your job is designing and producing machines or machine tools with the greatest possible *speed*, why waste time and labor devising *drives* to operate them? Why, when the R & M Machine Drive —compact, streamlined and performance-proved in hundreds of applications—may be *built in* as a complete unit?

The 3 or 6 speeds this drive provides—depending on whether a 1 or 2-speed motor is specified—are adequate to meet practically *every* operation requirement. Spur-type gears of high-grade, heat-treated steel are instantly, easily shifted. And best of all, the R & M Machine Drive is powered by the famously dependable R & M motor!

Chances are that this drive can be fitted to your machines without even a minor change. But if not, our drive engineers are at your service. Why not investigate . . . *now?*



On one of his seven R & M Machine Drive installations, S. H. Arnolt, general manager of the Arnolt Motor Company, demonstrates the ease with which gears are shifted. His firm is currently setting records in production of precision aircraft engine parts.

★

R & M MACHINE DRIVES INCREASE OUTPUT 10%

S. H. Arnolt, whose judgment combines the experience of a trained engineer and a production expert, says: "The engineering, neatness and compactness of the R & M Machine Drive are highly superior. Production increases credited to our seven installations average 10%. We have investigated and used most of the other drives, but all of our *new* installations will be R & M!"

★

CHECK THESE R & M FEATURES!

R & M INDUCTION MOTOR. NEMA. 3-phase, 220-440 volt. 1, 1½, 2, 3, 5 and 7½ h.p. at 1725 and 1140 r.p.m. 1 and 2 speed. Reversible.

OIL LEVEL INDICATOR. Bayonet-plug type, conveniently located on top, makes "oil-checking" easy.

GEARSHIFT. Rack and pinion mechanism. Only gearshift with finger-tip control.

AIR VENTS. Assure ample motor cooling. Motor will stand reversal by plugging at light loads for short periods without excessive heating.

MAIL THIS COUPON TODAY FOR FULL DETAILS

ROBBINS & MYERS, INC., Springfield, Ohio
(In Canada: Robbins & Myers Co. of Canada, Ltd., Brantford, Ontario)

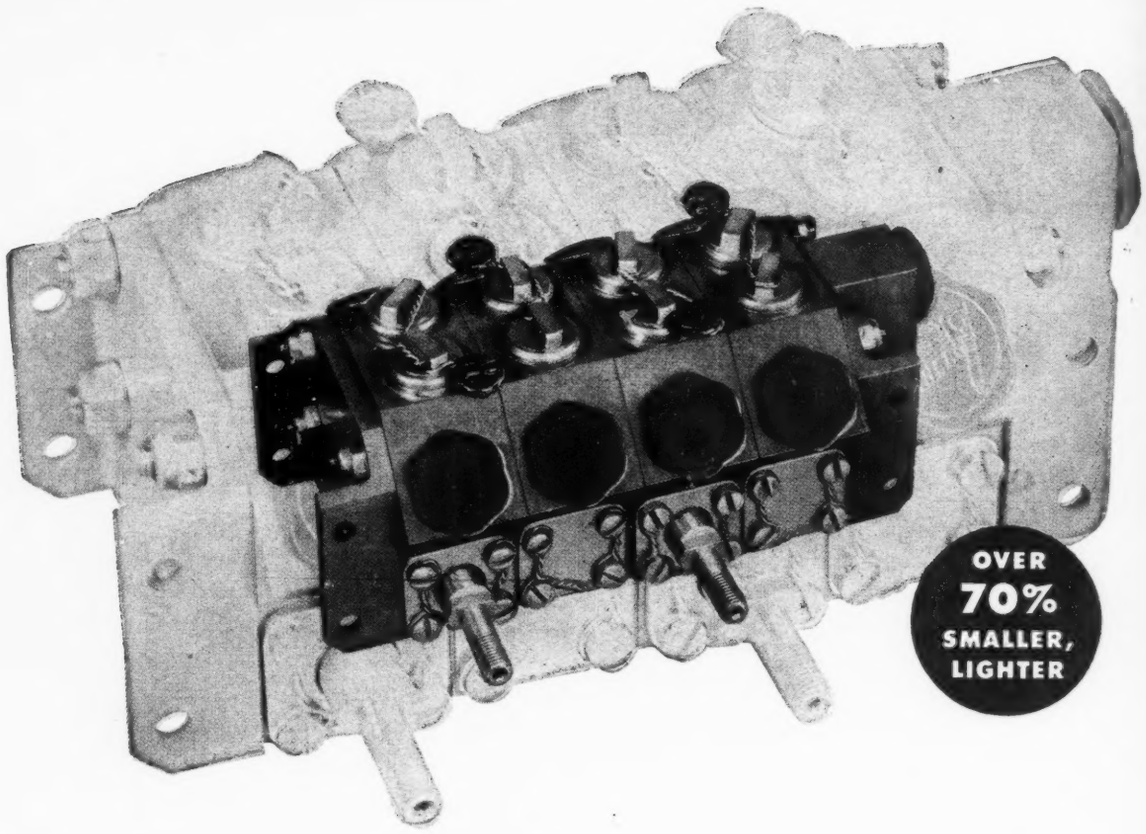
Please send information about the R & M Machine Drive.

Firm Name .....

Address .....

City ..... *State* .....

By .....



Smaller Space – BIGGER PROBLEM

AIRCRAFT and industrial engineers faced with the problem of installing bulky controls in limited space will welcome the new ADEL Stacking Midget. Utilizing the original ADEL Single Unit Mighty Midget 4-Way Hydraulic Selector Valve which revolutionized previous conceptions by offering space savings of 72% and weight savings of 76%, with performance characteristics actually superior to predecessor models, Stacking Midgets permit the installation of several small size, high capacity valves in a closely confined area. Quadruple Unit illustrated measures only $5\frac{31}{32}$" x $3\frac{3}{16}$" x $2\frac{7}{16}$" with flanges and shafts; weighs only 2.9 lb.

Any number may be clamped together by means of "thru" bolts and end plates which also serve as mounting brackets. All units are interchangeable. Symmetrical design permits turning end-for-end to secure desired shaft arrangement. Individual valve assemblies may be replaced by breaking only the two cylinder lines affected. Over-travel is prevented by an integral stop located on the camshaft. Normal servicing may be done by relatively unskilled persons without special tools.

In compliance with ADEL policy, individual working parts in the entire Midget Group are standardized to permit interchangeability between models and operating parts, economy in part stocks and maximum service facility. Bodies fabricated from dural bar stock to assure uniform strength, freedom from porosity, maximum dependability with minimum size and weight. Valve and camshaft assemblies manufactured from stainless steel, heat-treated to assure long service life. Critical dimensions obtained by grinding, micro-finishing and polishing on specially designed ADEL equipment.

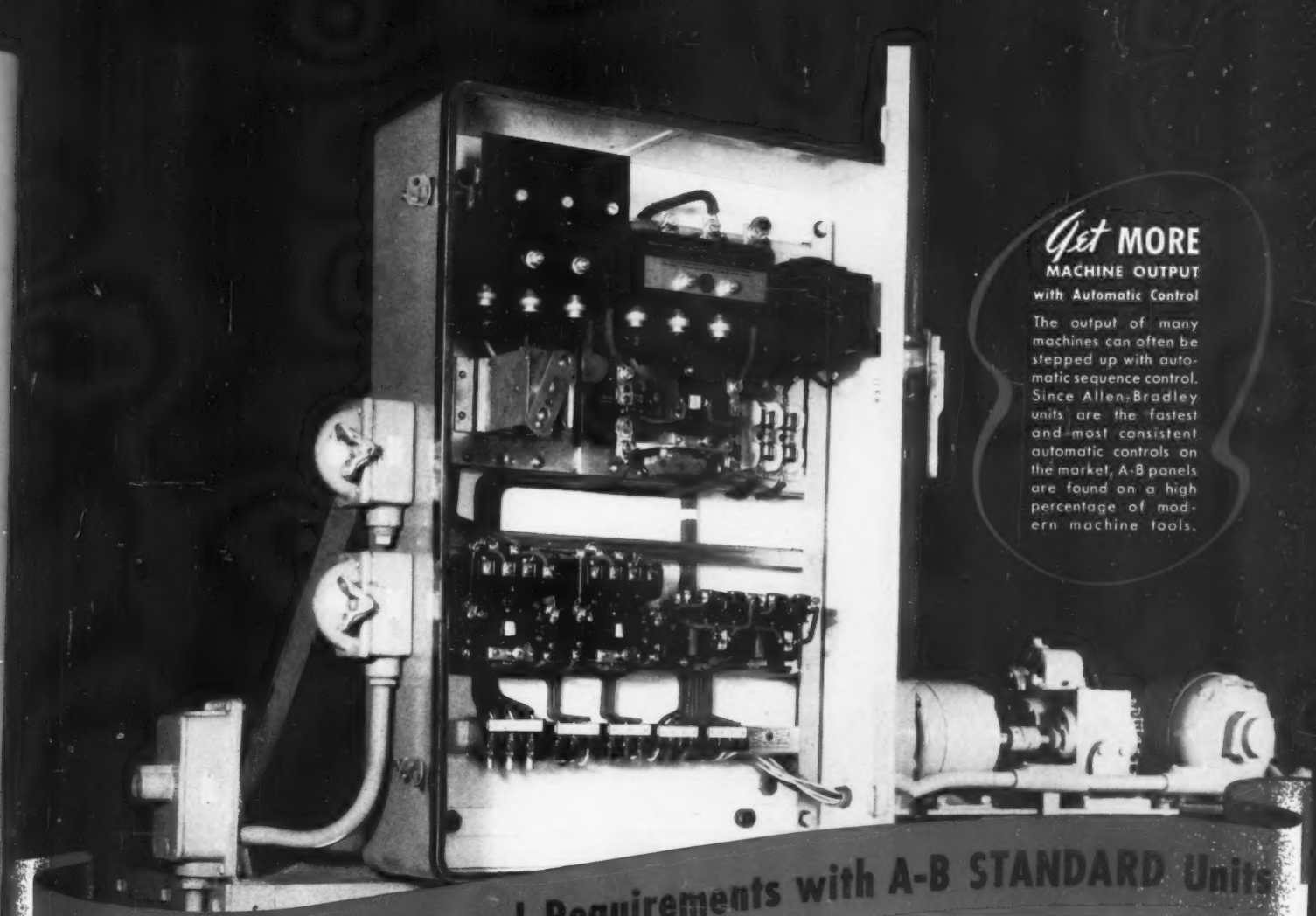
Contact nearest Engineering Service office for complete performance data and installation recommendations. Existing regulations permit submission of complete information only to individuals affiliated with recognized armament industries.

ADEL

PRECISION PRODUCTS CORP.

BURBANK, CALIFORNIA

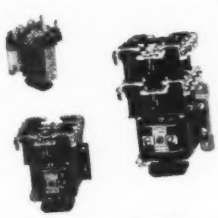
ENGINEERING SERVICE OFFICES: Administration Bldg., Love Field, DALLAS, TEXAS • 609 Stephenson Building, DETROIT, MICHIGAN • 1444 Washington Avenue, HUNTINGTON, WEST VIRGINIA • 303 Wareham Building, HAGERSTOWN, MARYLAND • 302 Bay Street, TORONTO, ONTARIO, CANADA



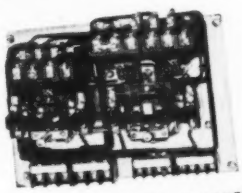
Get MORE MACHINE OUTPUT with Automatic Control

The output of many machines can often be stepped up with automatic sequence control. Since Allen-Bradley units are the fastest and most consistent automatic controls on the market, A-B panels are found on a high percentage of modern machine tools.

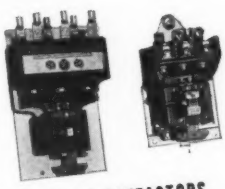
Satisfy Your SPECIAL Panel Requirements with A-B STANDARD Units



SMALL CONTACTORS

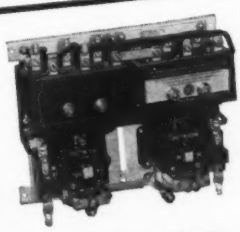


MULTI-SPEED MOTOR STARTERS

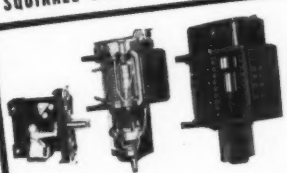


LARGE CONTACTORS

SQUIRREL CAGE MOTOR STARTERS



REVERSING SWITCHES



OVERLOAD and TIMING RELAYS

If your machines perform a definite sequence of operations, you can probably save critical materials by combining your control units on one control panel.

Special control panels need not mean special control units because Allen-Bradley engineers are constantly assembling intricate special panels using only standard units listed in the Allen-Bradley catalog.

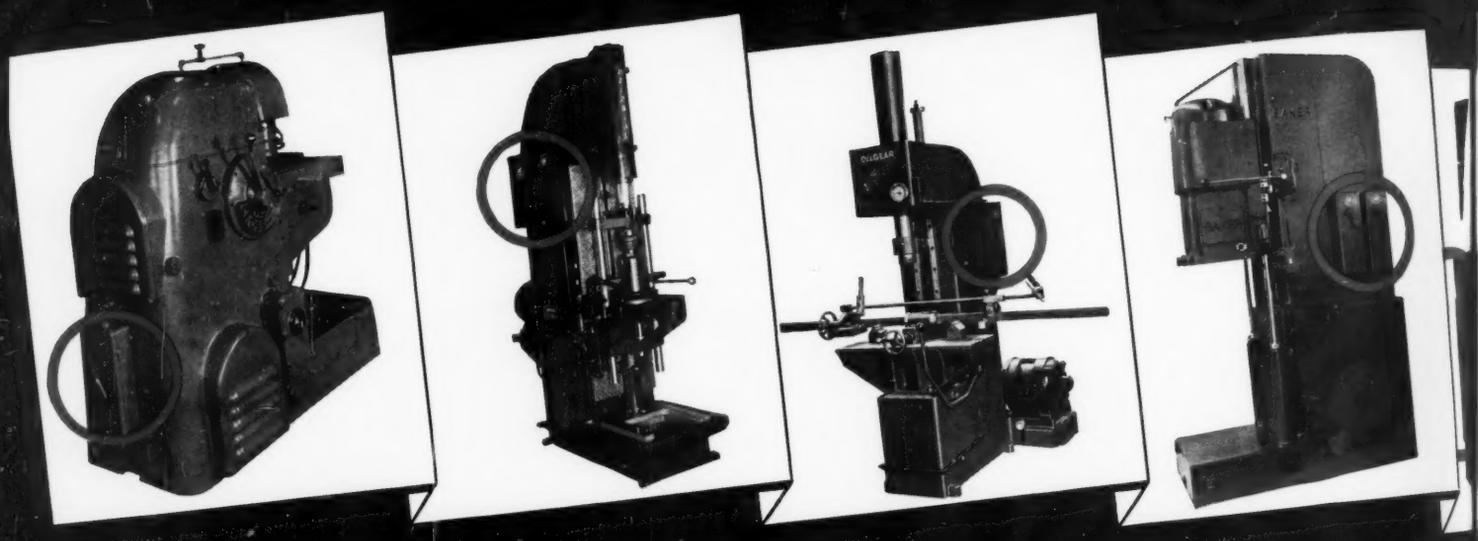
The A-B line consists of such a wide assortment of contactors, relays, switches, disconnects, and starting units of all sizes and types that it is a simple matter to develop complex control panels entirely of time-tested, reliable A-B units.

Don't risk the dependability of your machines by using "trick" control panels. Standardize on A-B panels. Then you will be safe... and save critical materials, too.

ALLEN-BRADLEY

AUTOMATIC MOTOR CONTROL

QUALITY



TYPICAL INSTALLATIONS OF ALLEN-BRADLEY BULLETIN 712 COMBINATION STARTERS ON MACHINE TOOLS

How to Save critical materials *in your motor starter installations*

The easiest and quickest way to save critical materials is to simplify your control installations. For example—don't use a motor starter and a separate disconnect switch when you can buy both in one cabinet. Here are the advantages of A-B Combination Starters:

SAVE WIRING—You eliminate the wiring and labor of connecting two separate units—starter and disconnect unit.

SAVE CONDUIT AND FITTINGS—You do away with the conduit, lock nuts, bushings, and other fittings required to hook up two boxes.

SAVE METAL BOXES—You dispense with one box (disconnect unit cabinets are usually large and bulky) and thereby save steel.

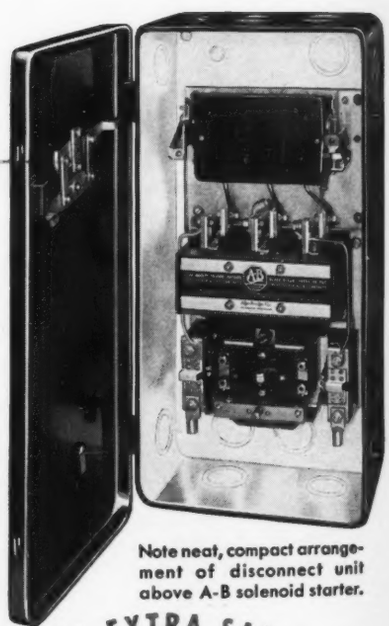
SAVE INSTALLATION TIME—You put up one cabinet—not two. That means less installation time and labor.

SAVE SPACE—You get a neater, more compact job with only one cabinet on the machine. See pictures above.

SAVE MAINTENANCE—Allen-Bradley solenoid starters and disconnect switches require no maintenance. The A-B patented silver alloy contacts in both units need no dressing or cleaning. There is only one moving part . . . no pins, pivots, bearings, or jumpers to cause trouble.

For full information, write for Bulletin 712.

Allen-Bradley Company, 1333 S. First St., Milwaukee, Wis.



Note neat, compact arrangement of disconnect unit above A-B solenoid starter.

—AND GET EXTRA SAFETY, TOO!

Cabinet cannot be opened unless disconnect lever is in OFF position. Switch can be padlocked by several maintenance crews to prevent reclosing before all of their jobs are completed.

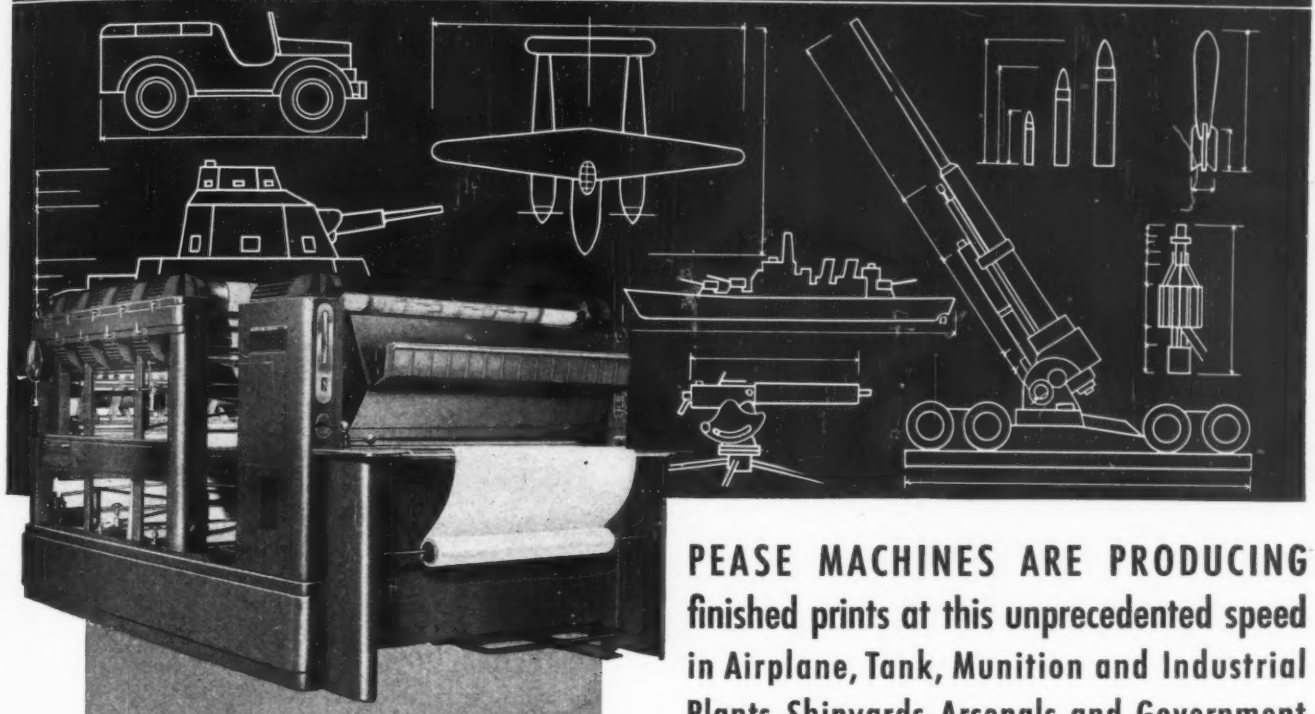
A-B Quality

ALLEN-BRADLEY

COMBINATION STARTERS

QUALITY

BLUEPRINTS AT 30 FEET PER MINUTE ARE HELPING TO BEAT THE AXIS



PEASE MACHINES ARE PRODUCING finished prints at this unprecedented speed in Airplane, Tank, Munition and Industrial Plants, Shipyards, Arsenals and Government Departments throughout the Nation

The number of Blueprints needed to beat the Axis simply staggers the imagination, for industrial plants and government departments need hundreds upon hundreds for shells, bombs, machine guns and anti-aircraft guns . . . thousands upon thousands for planes, tanks and jeeps . . . tons upon tons for battleships, carriers, transports and cruisers . . . for example, a recent tank improvement required almost 1000 pounds of Blueprints.

Blueprints have the all-important job of speeding the engineers' plans, details and specifications to the production lines, and Pease Model "22" Continuous Blueprinting Machines, with a practical production speed of 30 feet per minute, are helping America exceed its stepped up production program. They operate faster, more economically and require less attention, making sharper, clearer, more contrasty prints from pencil or ink tracings.

Write for complete information.

PEASE MODEL "22" FEATURES Speed Blueprint Production

★ **Sliding "Vacuum-Like" Contact** smooths out wrinkles, prevents errors.

★ **Three Speed Lamp Control** provides operation at 10, 15 or 20 amperes, does away with running speed and dryer heat changes.

★ **Actinic "No-break" Arc Lamps** burn for 45 minutes without breaking arc, resume instantaneously.

★ **Horizontal Water Wash** floats prints free from tension and prevents wrinkles, stains, bleeding.

★ **Chemical Applicator System** very economically allows change from Blueprints to Negatives in 30 seconds.

★ **Rapid Drying Drums**, heated either by gas or electricity, are thermostatically controlled.

THE C. F. PEASE COMPANY

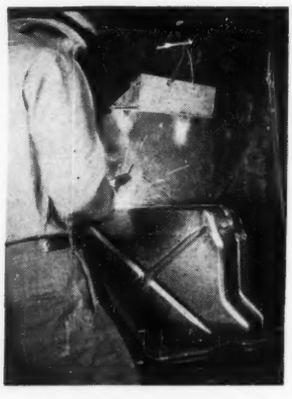
2606 WEST IRVING PARK ROAD • CHICAGO

Pease Blueprinting Machines

A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING

Here the handle is being welded into place by oxyacetylene welding.

Design it for Welded Construction!



Welding the two halves of the can together with the carbon arc.

THIS portable fuel or water container used by the U. S. Marines was designed to meet these requirements. Light weight combined with strength at the joints was realized by the use of both oxyacetylene and carbon arc welding. The component parts of each can are stamped out of light gauge metal and welded into a leak-proof unit so constructed that it will float when filled to prevent loss during landing operations.

Wherever product specifications call for light weight and rigidity, plus joint strength equal to or greater than that of the base metal, welded construction meets the requirements. Moreover welding conserves materials — makes possible faster production with lower manufacturing costs, factors of vital importance in peace as well as war.

Representatives of Airco's Applied Engineering Department will be glad to supply technical assistance on any problems of design or production concerning the use of welding and its allied processes.

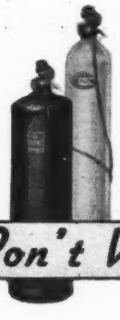
AIR REDUCTION

60 EAST 42nd STREET, NEW YORK, N. Y.

IN TEXAS: **MAGNOLIA-AIRCO GAS PRODUCTS COMPANY**

General Offices: **HOUSTON, TEXAS**

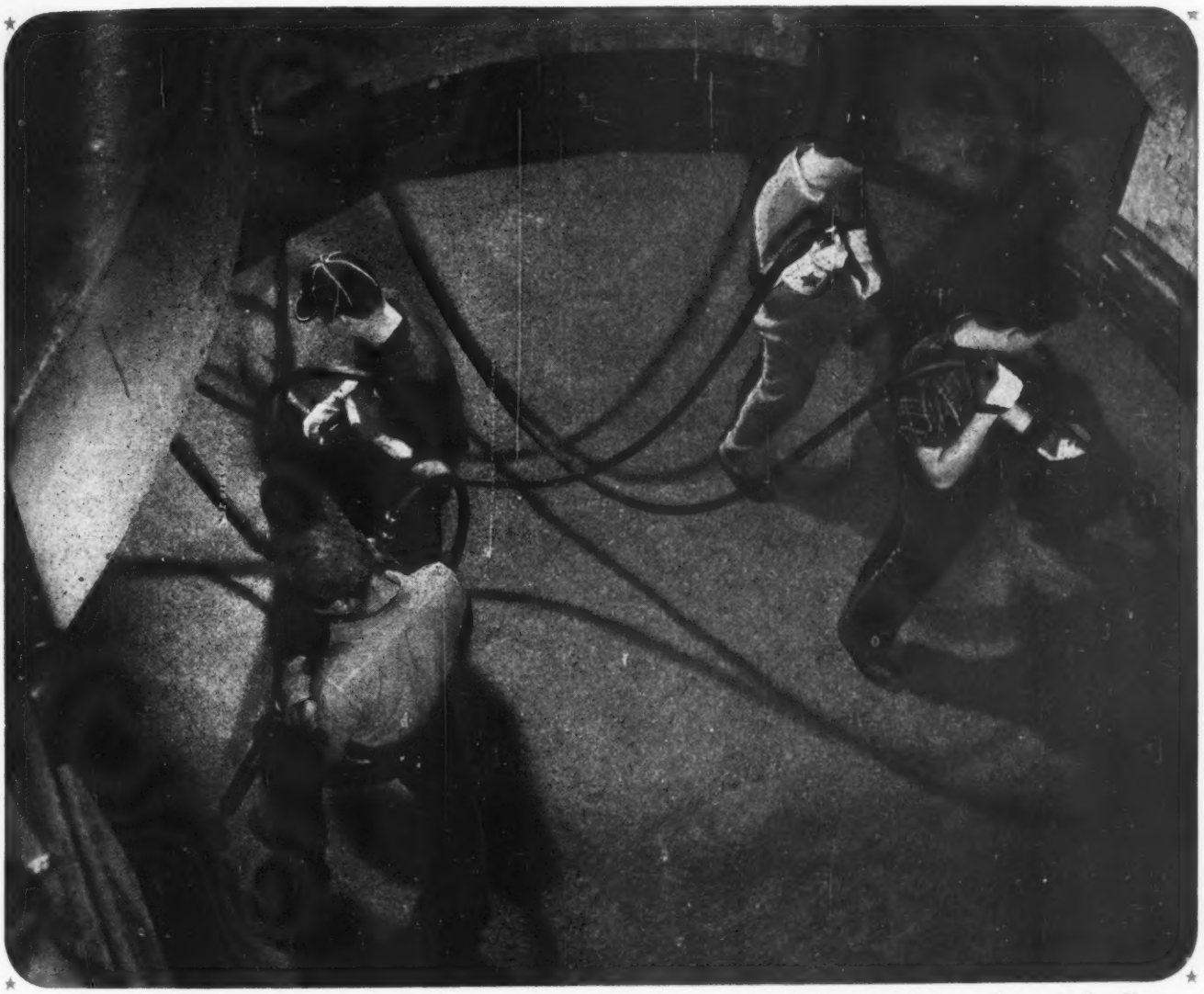
OFFICES IN ALL PRINCIPAL CITIES



AIRCO

WILSON

OXYGEN IS PRODUCTION — *Don't Waste it!*



OEM Photo by Palmer, in an Allegheny Ludlum Plant.

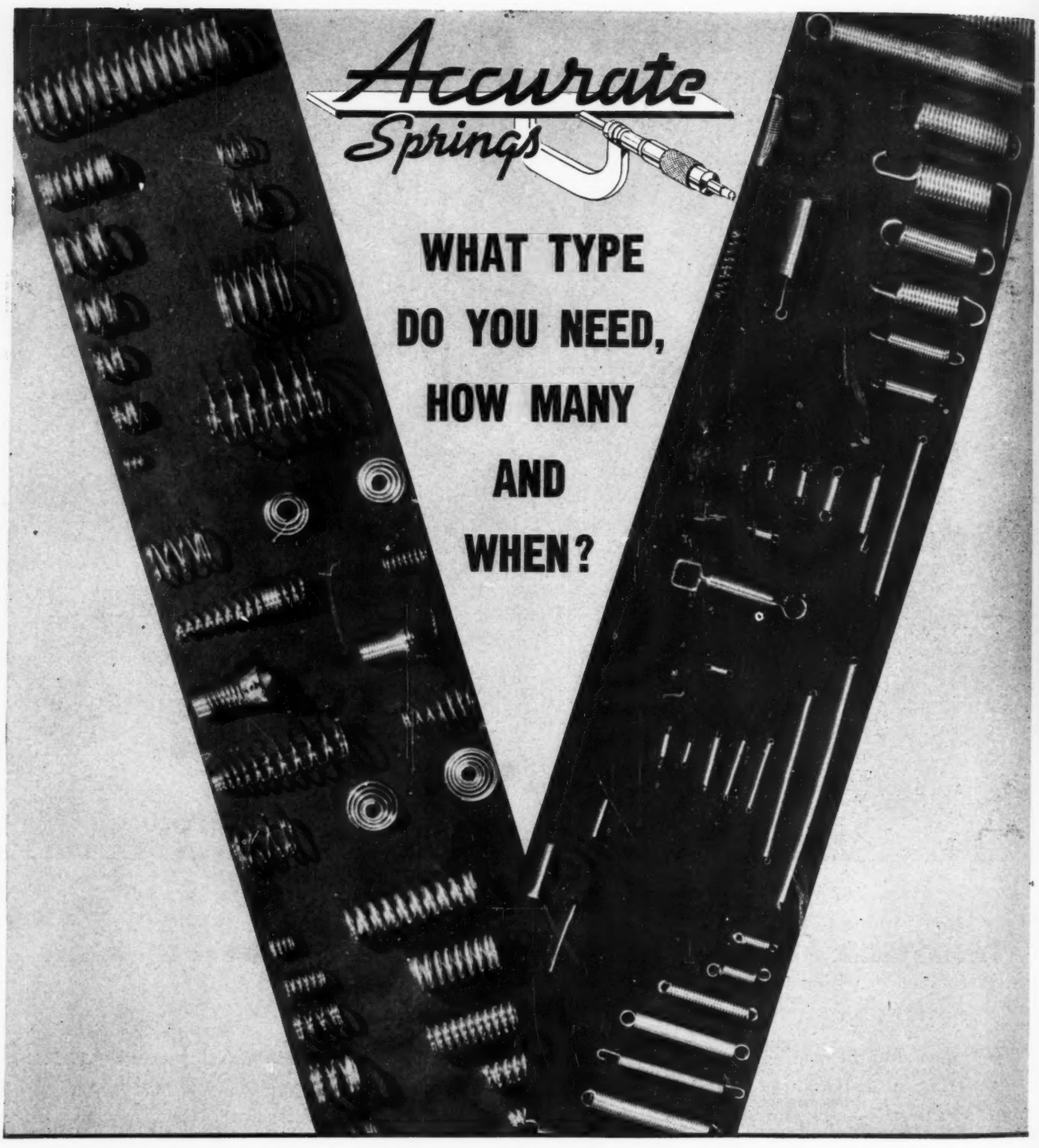
ANOTHER *Cooker* FOR THE STEEL BROTH OF WAR

TWO days after the men finished ramming in the bottom of this new 35-ton electric melting furnace, it was in full operation on stainless steel for the war assembly lines.

Allegheny Ludlum plant capacity has been expanded at record pace. Our output of stainless steels (tool, valve, and other alloy steels, too) has been doubled, tripled, quadrupled—as fast as the supply of alloying elements would permit it.

Production will continue to increase, but the appetite of war is insatiable in this critical year. It is imperative that the supply of stainless steel be made to go *farther,* by being used *better.* How much can rejects, spoilage, and all other forms of waste be reduced? Where can standard gauges, sizes and finishes be used instead of special ones; low alloys substituted for high? ● Help us, and let us help you, to protect and conserve the nation's supply of these vital alloys. Write or phone us for technical and fabricating data, or for the personal assistance of our Technical Staff.

Allegheny Ludlum
STEEL CORPORATION
GENERAL OFFICES: PITTSBURGH, PENNSYLVANIA



IF one of your problems is springs—dependable springs, that you must have in reliable quantities to keep your production at its peak—perhaps we can help you.

With our organization running in smoother-than-ever form we are producing more and faster and better products—to help *you* produce more, faster and better. We've learned short cuts and through experience have accumulated "know how" that is saving much time, trouble and headaches.

That is why we feel that your seemingly tough spring problem may find an easy answer here at Accurate. If you will show us what type—how many—and when you need springs or wireforms, we'll come up with answers you may find pleasantly surprising.

Send for the new Accurate "Handbook of Technical Data".
It's handy, compact, informative. You'll be glad to have it.

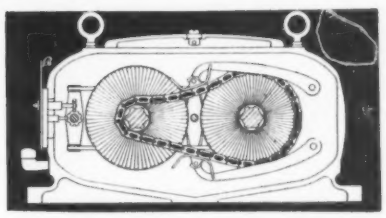
ACCURATE SPRING MFG. CO., 3813 W. Lake St., Chicago, Illinois

P.I.V. GEAR GETS ANY DESIRED SPEED INSTANTLY—MAINTAINS IT POSITIVELY AND ACCURATELY

By simply turning the hand wheel on the P.I.V. Gear, the ideal speed for each operation is obtained instantly, while machine is running. Can also be arranged for automatic, manual, vernier, direct or remote control.

Because there is no possibility of slippage in the drive and because speed changes are made while running, the P.I.V. Gear is continuously variable, providing an infinite number of speeds within its range and without steps.

There's Production Magic FOR VICTORY *in this Unique Device!*



The P.I.V. Gear is the only speed changer to employ a positive chain drive, thus assuring maintenance of the speed selected. Ends guess-work and speed hunting—widens the range and increases machine efficiency.

● With this unique, unusually compact, self-lubricating, fully-enclosed variable speed unit, you can build into your machines, the versatility needed to meet today's production problems—provides the ideal speed for each job.

Accurate speeds give uniform production, reduce waste of power and production spoilage. Tooth-to-tooth contacts give positive control. There are no "steps"; an infinite range of speeds, within a minute-fraction of a revolution, is possible. Available in horizontal and vertical mountings. Get the full story. Send for Data Book No. 1874. Link-Belt Company, Philadelphia, Chicago, Indianapolis, Atlanta, Dallas, San Francisco, Toronto. Offices, warehouses and distributors in principal cities.

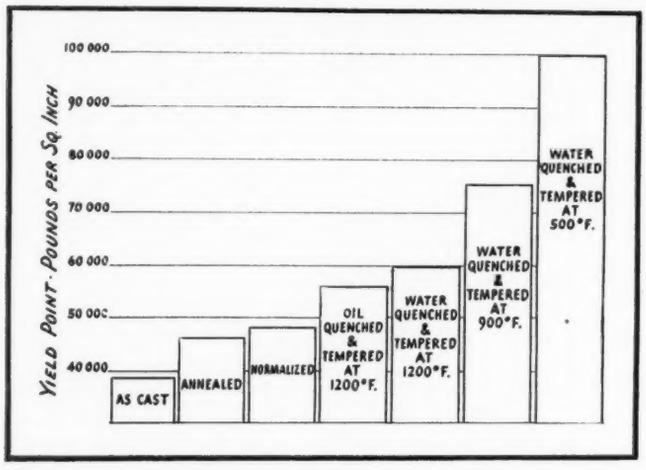
LET'S GO! U.S.A. · KEEP 'EM FLYING!

P876

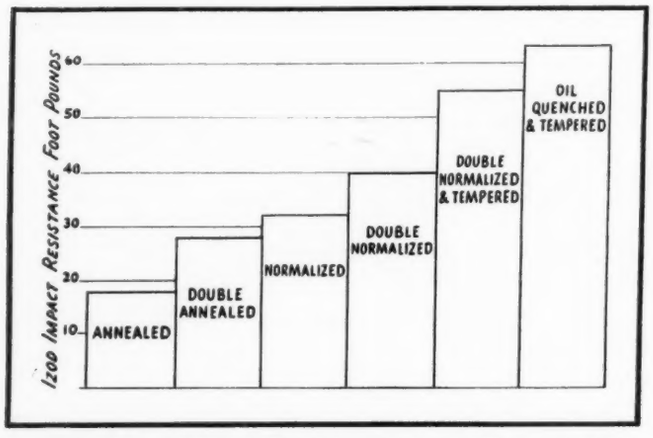
LINK-BELT P.I.V. GEAR

POSITIVE INFINITELY VARIABLE SPEED CONTROL

SPECIFY THE MATERIAL THAT FULFILLS ALL OF YOUR REQUIREMENTS ...NO MATTER HOW SEVERE THE CONDITIONS



Showing how the Yield Point of carbon cast steel may be increased by heat-treating.



Showing how Impact Resistance of an alloy cast steel may be increased by heat-treating.

Cast steel is a versatile material.

If you must have great strength and toughness, or extreme rigidity, or extra hardness, or resistance to wear, temperature, stresses, or fatigue, you can write your own ticket.

Cast alloy steels are produced with all of these characteristics, in any combination, and their desirable mechanical properties are readily enhanced by heat-treating.

Special alloys may be specified in limited quantities without the delay or extra cost of small mill runs—an important factor in war production.

Complicated shapes may be had in close to final form, yielding big savings in machining, finishing and assembly.

The charts on the left indicate the wide range of properties that may be obtained by heat-treating typical commercial cast steels.

This new booklet gives information on the mechanical properties of cast steel compared with other cast ferrous metals.

Address the Steel Founders' Society, 920 Midland Bldg., Cleveland, Ohio. Enclose 10c postage.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

Geared TO DO THE JOB

Common sense rules out the publication of specific facts and figures. But it's no secret that PERKINS GEARS are integral parts of airplane engines which power some of the deadliest fighters and bombers in the world.

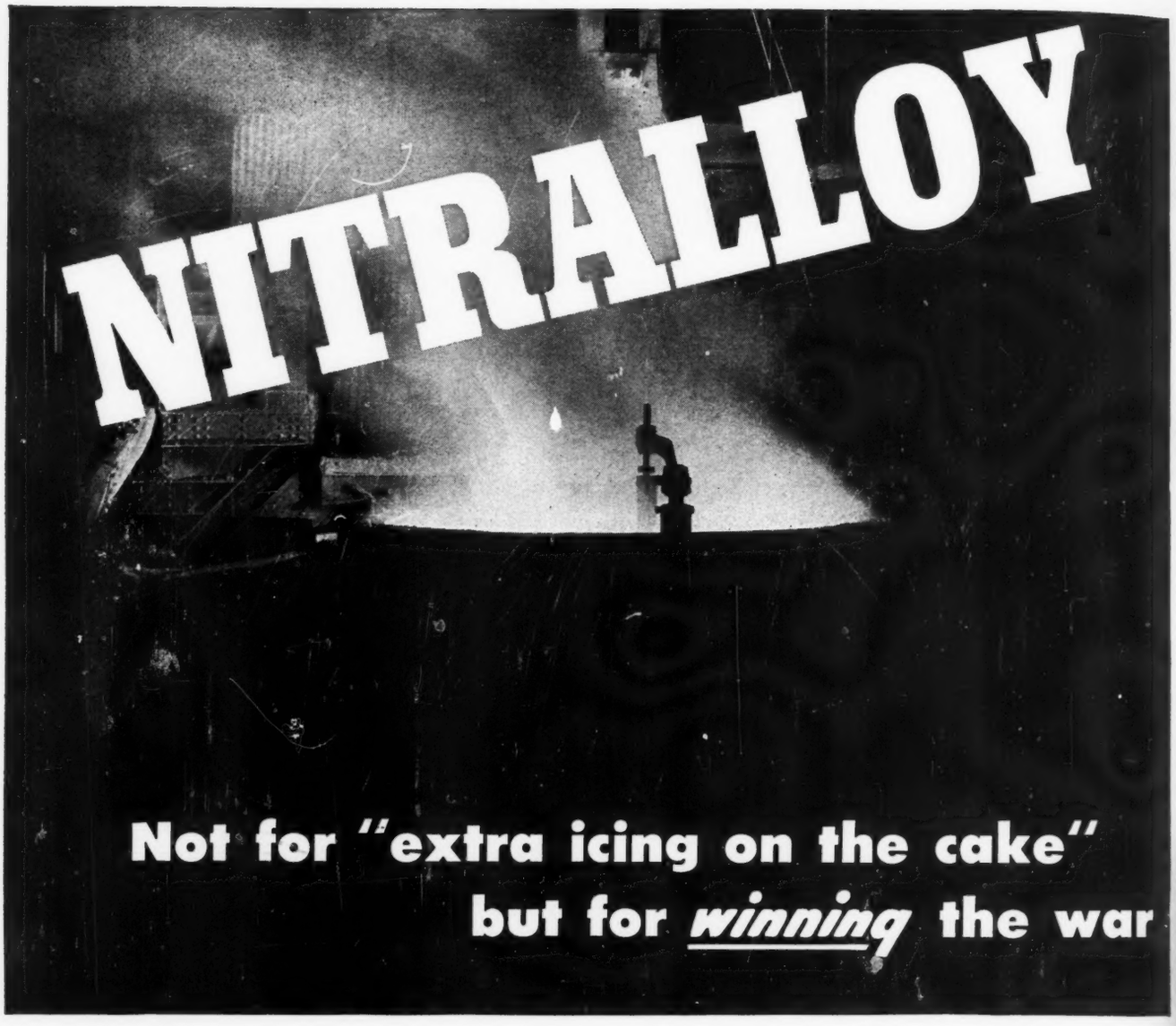
Perkins produces every type of precision gear exactly to your specifications, from any material, in any quantity, for aircraft motors, precision instruments or any other equipment needed for Victory.

PERKINS PRECISION, CUSTOM-CUT GEARS

help power American Planes

PERKINS MACHINE & GEAR COMPANY, SPRINGFIELD, MASS.

"Throw Your Scrap Into The Fight"



Editor E. C. Kreutzberg of "Steel" says this:

"It should be remembered that the present shortage of alloy steels results from the huge Army and Navy demand for them. The Generals and Admirals demand them, not because they want extra icing on their cake, but because tests and experience over many years have enabled them to determine what materials are best for the waging of war."

Nitralloy and the Nitriding process, producing the hardest steel surface known, are steadily going into the production of vital parts of planes, tanks, ships and other war equipment.

When a just and victorious peace again makes alloy steels more generally available, Nitralloy and the Nitriding process will contribute to industry their ability to the resistance of wear, fatigue, and abrasion.

For the present, Nitralloy Steels are available under government regulation where needed to help win the war. And that, above all, comes first.

THE NITRALLOY CORPORATION

230 PARK AVENUE · NEW YORK, N. Y.

Companies Licensed by The Nitralloy Corporation

ALLEGHENY LUDLUM STEEL CORP...WATERVLIET, N. Y.
BETHLEHEM STEEL CO.....BETHLEHEM, PA.
COPPERWELD STEEL CO.....WARREN, O.
CRUCIBLE STEEL CO. OF AMERICA..NEW YORK, N. Y.
FIRTH-STERLING STEEL CO.....McKEESPORT, PA.
REPUBLIC STEEL CORPORATION.....CLEVELAND, O.
THE TIMKEN ROLLER BEARING CO.....CANTON, O.
ROTARY ELECTRIC STEEL CO.....DETROIT, MICH.
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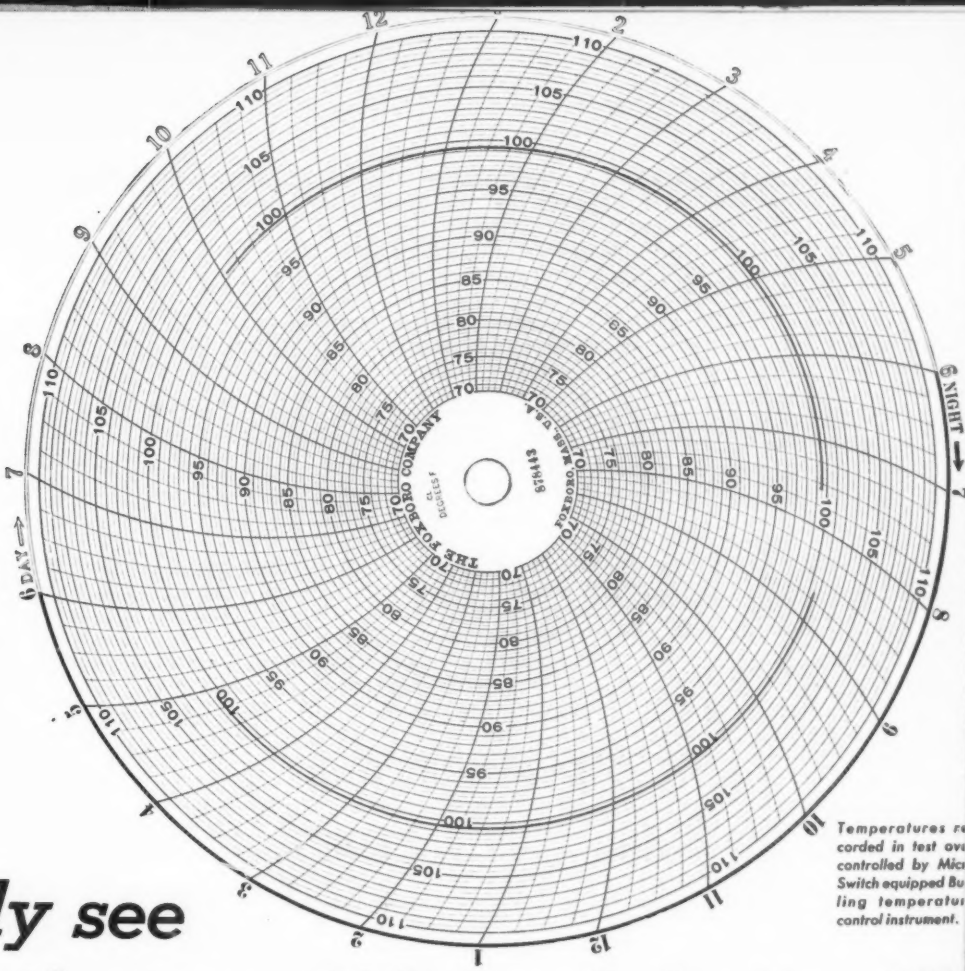
3221

Memo
MICRO SWITCH

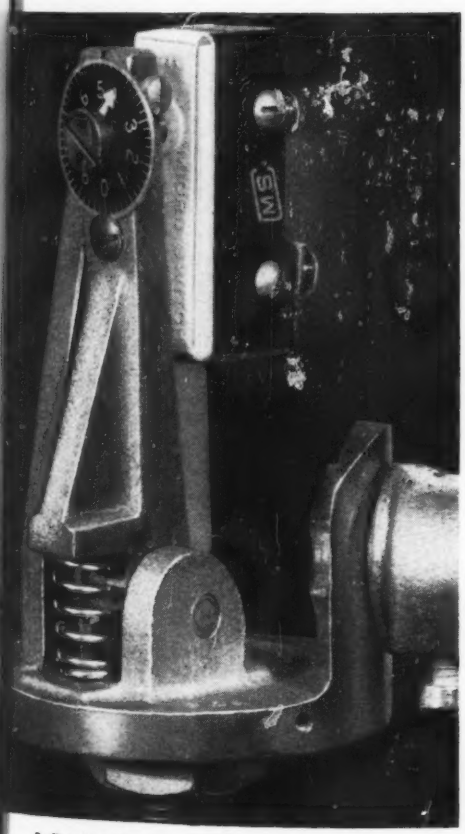
"They specified ±1/8° F.



Temperatures re corded in test ove controlled by Mic Switch equipped Bu ling temperatu control instrument.

..you can easily see from the chart that we did much better!"

Herbert S. Burling, President
BURLING INSTRUMENT COMPANY
253 Springfield Avenue, Newark, N. J.



Burling Model V-I Micro Switch operated temperature control, shown with cover removed. The special V-I instrument that gave the extreme accuracy recorded in the chart employed a special Type WZ-R Micro Switch with .0001" movement differential.

In vitally important plants in this and other nations fighting for freedom, Burling instruments are controlling temperatures as low as —100° F., as high as 1400° F. The temperature chart reproduced here shows the extreme accuracy obtained with a special Model V-I instrument constructed for laboratory use, employing a special Type WZ-R Micro Switch with .0001" movement differential.

Burling temperature control instruments are activated by precision snap action Micro Switches. In the Burling Model VD-II, for example, two Micro Switches make it possible to control heating or cooling or both; to control the temperature and give either high or low limit control; to give 2 or 3-step control; to give floating control with reversing control motors; to give 2 or 3-speed control of auxiliary motors.

Burling Model VD-II (with cover removed).

Micro Switch dependability, precise action, and small size are ideal characteristics in this and hundreds of other process or product applications. The thumb-size basic Micro Switch weighs only an ounce, yet operates at the same point through millions of operations, on pressures as low as 1¼ ounces, and movements as low as .0002". Listed by Underwriters' Laboratories with ratings of 1200 V.A. loads, from 125 to 600 volts A.C.

Micro Switches can be supplied in a wide range of types and housings. Every engineer should have a copy of our Catalog No. 60. The operating principles and applications of Micro Switches are described in detail. New Catalog No. 70 describes Micro Switches for aircraft and similar applications.

Copyright 1942, Micro Switch Corporation

Micro Switch is a trade name indicating manufacture by Micro Switch Corporation.

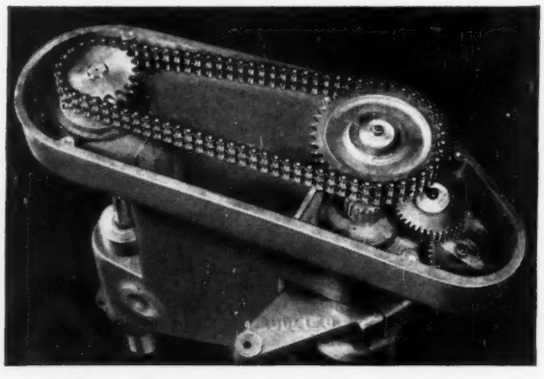
MICRO MS SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation Sales Offices: New York, Chicago, Boston

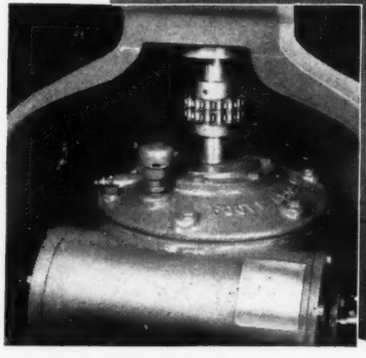
12 Millionths Limits on Famous ULTRA-LAP Machines

MORSE *"Engineered to the Job"* CHAIN DRIVES *INSURE* Positive and Flexible Power Transmission

Thanks to the precision control of Ultra-Lap Machines—lapping or surface finishing of vitally needed war parts can now be put on a production basis, in fact, stepped-up 700% over the slow hand process. ¶Ultra-Lap Machines make practical a degree of flatness of finished parts not possible by any other method. They rapidly produce metal surfaces that are optically flat, within 12 millionths of an inch or one micro-inch R.M.S. for smoothness. ¶Such precision demands unerring power transmission. Morse "Engineered to the Job" Roller Chain Drives and Couplings are doing the work—transmitting power smoothly, economically and at practically 100% efficiency. You, too, can have the benefit of Morse Drive Equipment . . . call your local Morse Representative.



Front spindle of Ultra-Lap Machine is driven with Morse Roller Chain Drive as illustrated above. This drive eliminates any possibility of slip, regardless of load—so important in precision lapping. Note compact design.



In order to compensate for slight shaft misalignment, a Morse Roller Coupling is the connecting medium between reduction gears and drive shaft.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

Making the Enemy DIE

FOR HIS COUNTRY

VICKERS

HYDROMOTIVE CONTROLS

Soldiers of the U. S. Army are now given this maxim: "It is commonly supposed that the primary duty of a soldier is to die for his country. This is not true. It is his duty to make the enemy die for his."

The spirit of aggressiveness which this reveals should be heartening to every American, and all Americans will want to do everything they can to make the enemy "die for his country" in this war of survival.

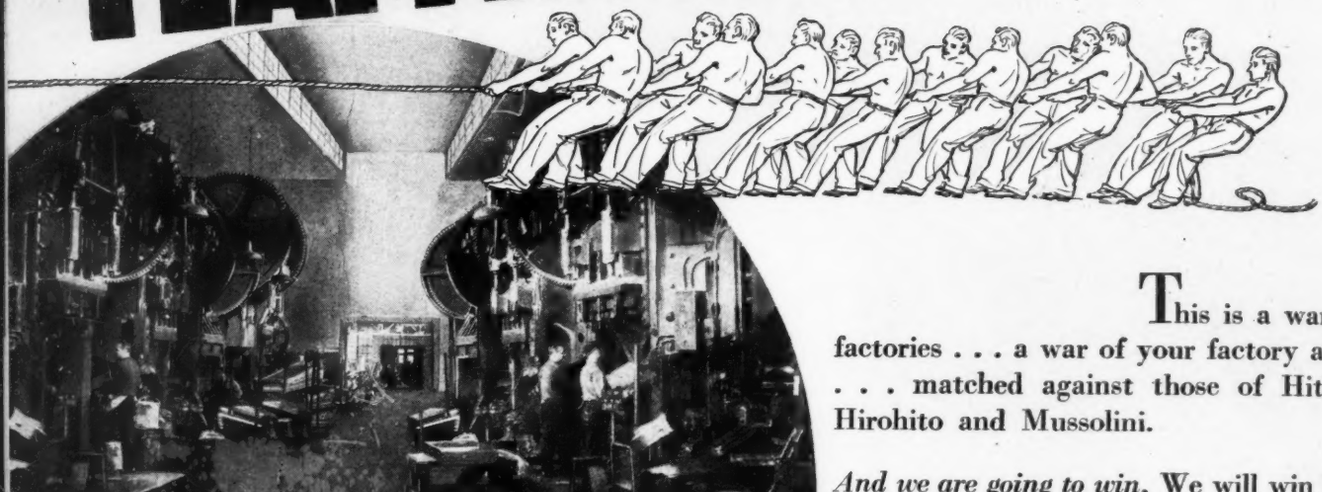
Vickers Incorporated is contributing to this effort on many fronts. Vickers Hydromotive Controls on our war machines have helped compel many an enemy into this sort of heroism. These high pressure oil hydraulic controls are dependable, accurate, easy to operate, easily adjusted, insensitive to vibration and shock . . . reliable no matter how tough the going.

VICKERS *Incorporated*

1430 OAKMAN BLVD., DETROIT, MICHIGAN

Engineers and Builders of Oil Hydraulic Equipment Since 1921

TEAMWORK *will win!*



This is a war of the factories . . . a war of your factory and ours . . . matched against those of Hitler and Hirohito and Mussolini.

And we are going to win. We will win because American industry's unmatched ability to produce has a bedrock foundation of *Teamwork* . . . teamwork of specialists who are working together as a united, huge war production machine.

No single plant is self-sustaining. It depends upon other factories for raw materials, for vital parts and equipment. Yet, every need can be supplied. *American industry is rolling.* When your plant needs materials, tools, or equipment, it can successfully seek out a source which has learned the job of building and servicing its product superbly well.

Right now we realize the supreme importance of Ross Air Control Valves to the war production program. Warships which ply the seas . . . planes which patrol the air . . . tanks and guns . . . all are built in plants equipped with Ross Air Control Valves. Many of these plants . . . probably yours . . . are working two and three shifts a day . . . six and seven days a week . . . packing two or three years of normal use of equipment into one.

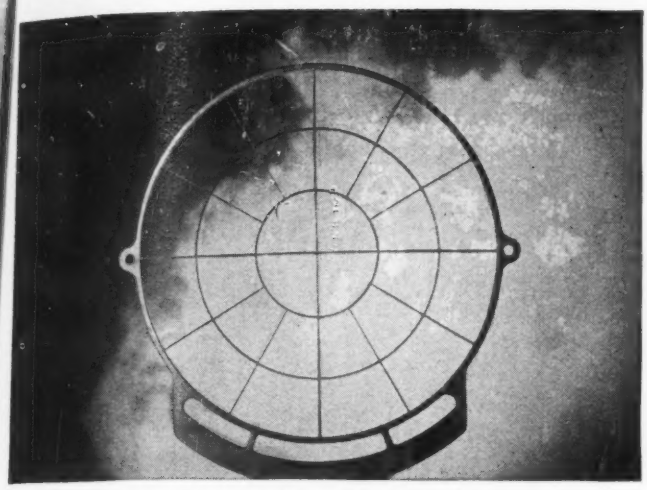
Keep the air control valves in your plant *on the job.* Our Nation wide service will help you do it. *Air control valves are our business . . . and our only business.* Our big job right now is to help you keep your air control valve equipment operating at full efficiency. Let's "team up" . . . *Teamwork will win!*

★A SIZE AND TYPE FOR EVERY OPERATION★

ROSS *Operating* VALVE CO.

6485 Epworth Boulevard, Detroit, Michigan

DIE CAST GUN SIGHTS FOR THE FIGHTING FRONTS



The cross ribs are under .050″ in section thickness.

All metals and methods of fabrication will eventually find their proper places in the war effort. To the extent that special high grade zinc is available, and with high speed die casting equipment to be utilized for those applications where it can be of maximum value, a wider use of ZINC Alloy Die Castings probably lies ahead.

Our British Allies have, for example, been employing die castings of ZINC Alloy for a variety of war items which are not so produced in this country. Consider the Canadian-made anti-aircraft gun sight shown above. Although the diameter of this gun sight is 11¼″, it has been possible, through ingenious die design, to chase the metal for the cross ribs in section thicknesses which range only .035″ to .050″.

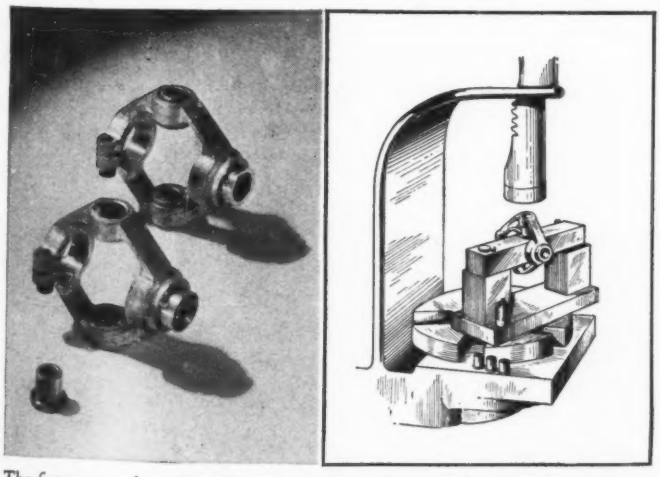
The requirements of dimensional accuracy, production economy and strength for this gun sight all come well within the scope of ZINC Alloy Die Castings.

A CLEVER FIXTURE FOR BUSHING INSERTION

A worker in the assembly department of a Company which uses large quantities of ZINC Alloy Die Castings has developed a clever fixture for bushing insertion. This fixture guards against possible distortion in a thin section of metal, by so supporting the die casting that the stress of insertion is taken by the boss around the bushing hole.

The part in the illustration is a differential gear carrier in the form of a spider. The casting is slipped over a pivoted bar which is swung back against a stop. This bar supports the bushing, flange end down, and holds it in place for the arbor press ram.

Because the bushing, when seated, protrudes above the surface of the casting, a hollow punch is used between the press ram and the casting at the end of the insertion stroke. This punch is placed over a pin next to the supporting block on the fixture when not in use (see sketch).



The fixture guards against distortion and speeds up production of a war item.

THE New Jersey zinc

FOR VICTORY BUY UNITED STATES WAR SAVINGS BONDS STAMPS

ALLOY POT

A publication issued for many years by The New Jersey Zinc Company to report on trends and accomplishments in the field of die castings. Title Reg. U. S. Pat. Off.

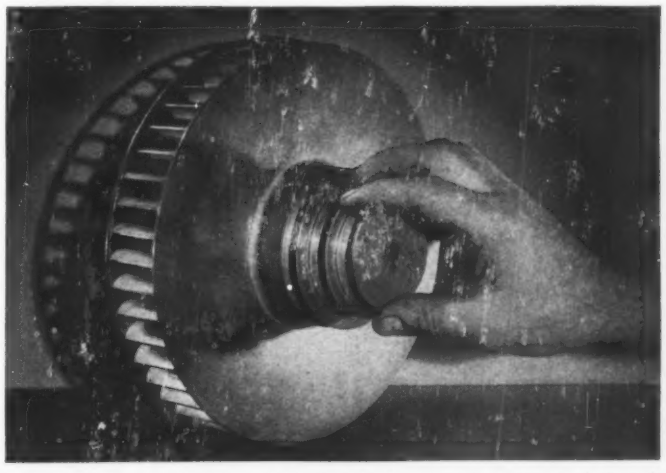
MACHINE DESIGN EDITION **No. 3**

THE ECONOMY OF ZINC ALLOY DIE CASTINGS

The pulley hub, the face and the blades of the 9¼″ ZINC Alloy Die Cast rotor shown below are all integrally cast. By what other means could this blower rotor have been produced—in one piece—without costly assembling and machining

There are many physical reasons behind the adoption of ZINC Alloy Die Castings but, basically, the deciding factor is economy—the material and manufacturing method which will do the job best at lowest cost.

For further examples of this economy, ask us—on your company letterhead—for copies of five booklets illustrating ZINC Alloy Die Casting applications in five major peace-time consuming fields.

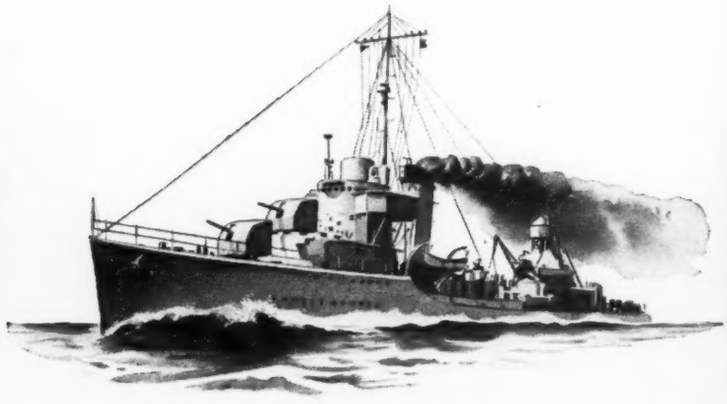


Not shown is a metal saver with strengthening ribs—between the hub and the largest diameter pulley.

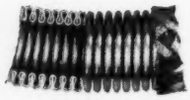
THE NEW JERSEY ZINC COMPANY 160 FRONT ST., NEW YORK CITY

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

For a 1/8-inch oil can spout or a 6-inch fueling line for war-dogs



Perhaps the most intriguing angle of flexible metal hose and tubing is its seemingly endless range of application. Using practically any workable metal, we can build flexible hose or tubing for anything from a simple spout to a high pressure seamless hydraulic line that can be flexed millions of times without breaking —a line that will give you the flexibility of garden hose, the dependability of metal and the *strength of rigid pipe!*



American Seamless — corrugated from seamless rigid tubing . . . no welds, laps or joints . . . made in several alloys.

Whether you need a flexible connector for misaligned or moving parts, for isolating vibration, for conveying air, water, oil, steam or fuel, you'll likely find we have a type of flexible metal hose or tubing that will do the job more capably.

American Interlocked —wound of strip metal, joints packed; the toughest type of extremely flexible metal hose.

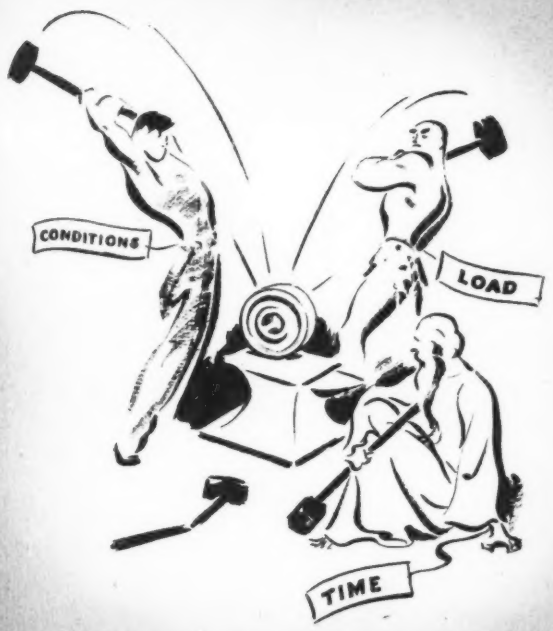
ANACONDA

42190

American Metal Hose

AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY • General Offices: Waterbury, Conn.
Subsidiary of Anaconda Copper Mining Company • In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ontario*

They're BUILT to take a beating...

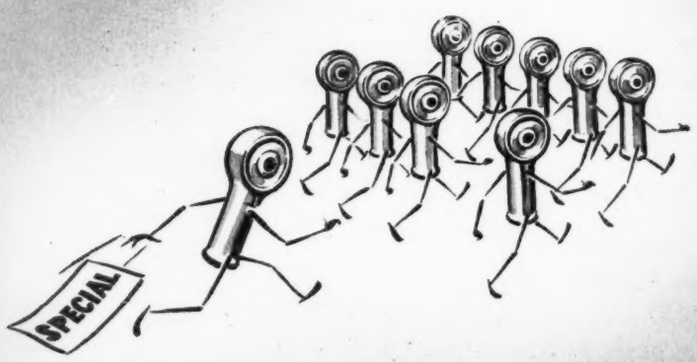


They are the Fafnir Ball Bearings that the Machinery Makers "bury"! They're big and rugged . . . built to last a lifetime in the *inaccessible spots*. They're the kind of ball bearings that require no pampering . . . and deep in the heart of a giant press, or blooming mill, or whatever . . . they work dependably and efficiently under the most punishing load and operating conditions. They're truly built to take a beating!

Fafnir Heavy Duty Ball Bearings, like all bearings of the complete Fafnir line, incorporate the time-proved Fafnir Balanced Design. This means larger balls and deeper races for greater strength and ruggedness . . . for greater radial and thrust capacity. Your requirements may not demand such brute strength in a ball bearing . . . but you are interested in the performance they typify which is reflected in all Fafnir Ball Bearings. The Fafnir Bearing Co., New Britain, Conn.

FAFNIR
MADE IN USA
The Fafnir Ball Bearing pictured here is the No. 320 Medium Series, with a load capacity of 36,380 lbs. at 50 R.P.M. Designed for use on horizontal shafting to handle heavy radial loads. A corresponding bearing, for vertical shafting to handle heavy thrust loads, is the Fafnir Thrust Ball Bearing No. N1820.
ARMY E NAVY
FAFNIR
Ball Bearings
THE BALANCED LINE
FOR ORDNANCE, AIRCRAFT AND
INDUSTRIAL MACHINERY

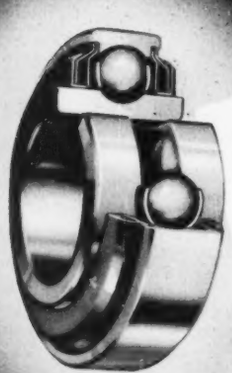
Once a special *not* always a special



Just when does a "Special" bearing become a "Standard" bearing? The logical answer seems to be . . . "when it solves a problem that is common throughout a particular industry, and when the demand for this *better* bearing is universal and continuous." In this event, the bearing goes into regular production and becomes a "Standard" in the line.

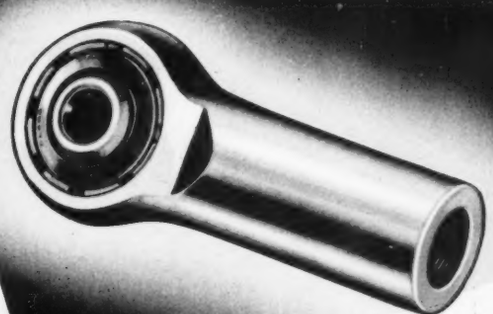
There are many such ball bearings in the Fafnir line . . . the original "Specials" have become standard because they do a job better and more efficiently than it had ever been done before.

The willingness of Fafnir engineers to tackle problems confronting bearing users in every industrial field has resulted in the over-all superiority and broadness of the Fafnir line. Time and time again, the selection of Fafnir Ball Bearings has been the "turning point" to greater machine operating efficiencies . . . savings in power transmission and low-cost, maintenance-free operation. Bearing users searching for outstanding bearing performance on common and unusual applications have ended their quest with Fafnirs. The Fafnir Bearing Company, New Britain, Conn.

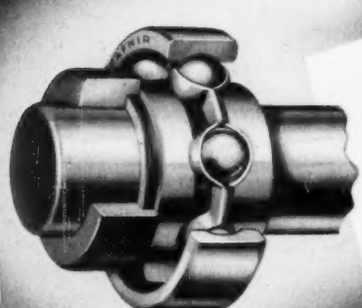


Problem: Excessive Dirt and Dust.
Solution: FAFNIR "MECHANI-SEAL" BALL BEARINGS—*a 100% efficient labyrinth sealed bearing. Close tolerances rather than rubbing members seal dirt out, lubricant in. No friction or drag.*

Problem: Lack of Space
Solution: FAFNIR EXTRA-COMPACT BALL BEARINGS—*so compactly built that a shaft 40 m/m in diameter, for instance, needs a housing bore of only 68 m/m instead of the usual 80 m/m! For the machine designer who wants precision bearings with greater load capacities.*



Problem: Sloppy or Binding Aircraft Control Pushrods.
Solution: FAFNIR SELF-ALIGNING BALL BEARING UNITS—*assure sensitive, rigid, frictionless aircraft control. Now standard equipment on every type of aircraft.*



Problem: Installation
Solution: FAFNIR WIDE INNER RING BALL BEARINGS, *that you don't have to hammer on and hammer off your shafts. They slip over the shaft and become rigidly engaged by a simple turn of a Locking Collar. Just as easily disengaged.*

ARMY E NAVY

FAFNIR
Ball Bearings

THE BALANCED LINE
FOR ORDNANCE, AIRCRAFT AND INDUSTRIAL MACHINERY

LINCOLN CENTRO-MATIC LUBRICATING SYSTEMS

cut down on bearing failures and prevent delays in producing war orders

Easily installed on new or old machines...Lubricate all bearings from a single source--quickly, economically

Basically all Lincoln Centro-Matic Systems are the same. A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a hand operated or a power operated Centro-Matic Lubricant Pump. A power operated system can be semi-automatic or it can be full automatic. The injectors can be grouped in manifold or located separately at each bearing. In either arrangement only a single lubricant supply line is required. 142-17

For details, please write for Bulletin 888

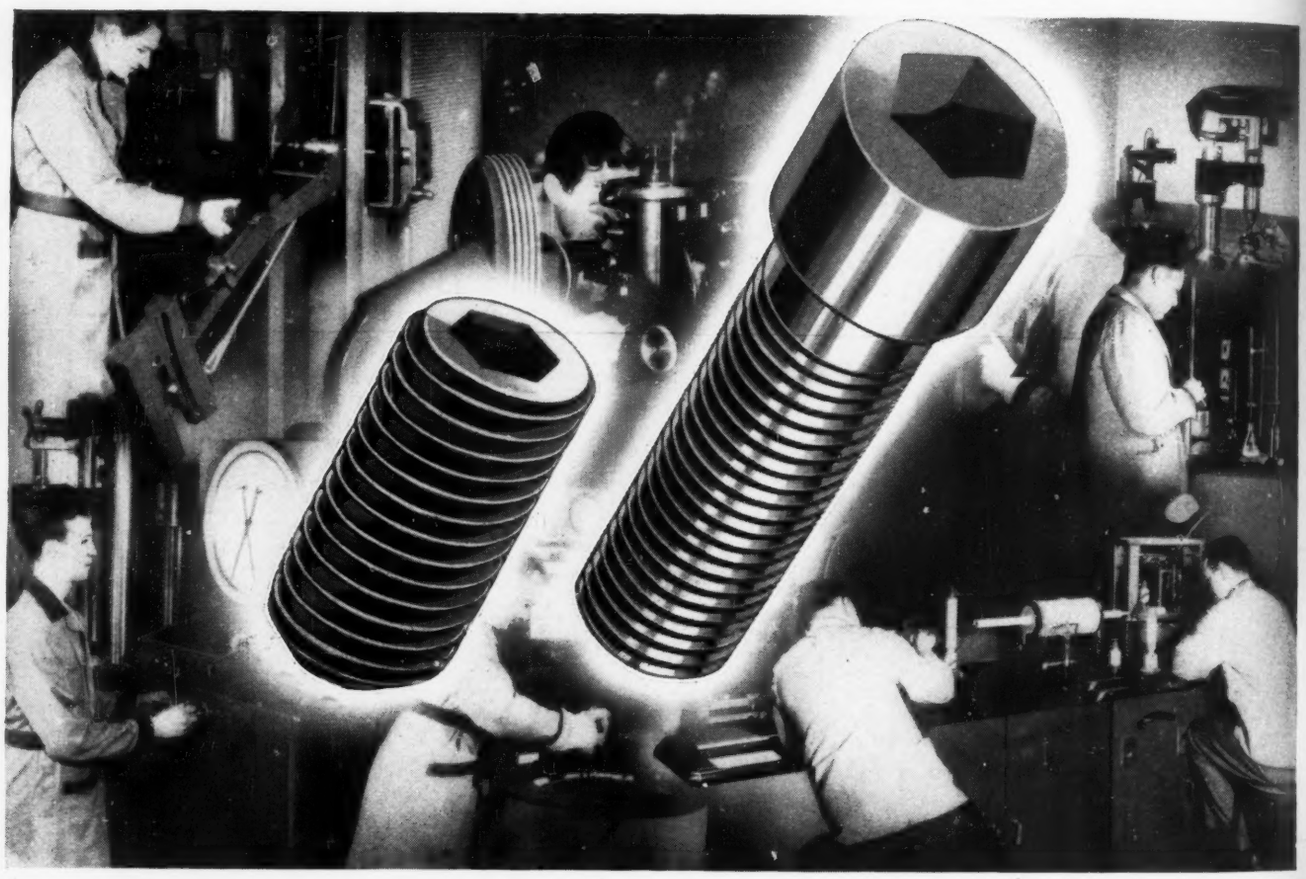
ARMY-NAVY PRODUCTION AWARD for high achievement in the production of war equipment has been conferred upon the Lincoln Engineering Company. It serves as inspiration toward greater and greater accomplishment until the time of final and complete Victory.

LINCOLN ENGINEERING COMPANY

Pioneer Builders of Engineered Lubricating Equipment

ST. LOUIS, MO., U. S. A.

Right in EVERY DETAIL– to make every working hour count!



Every Parker-Kalon Socket Screw is quality-controlled by a unique routine!

Physical and dimensional characteristics of Parker-Kalon Socket Screws are maintained well beyond generally accepted standards. Parker-Kalon's Quality-Control Laboratory – without counterpart in the screw-making industry – stands guard over every detail. "Doubtful screws" – screws that *look* all right but some of which fail to *work* right – are eliminated by a rigid, step-by-step check routine that begins with a careful analysis of the special alloy steel. This extra dependability is paying dividends to countless users who must today make every working-hour, every man-hour count. Yet, it costs no more to specify PARKER-KALON! Parker-Kalon Corporation, 192-200 Varick Street, New York, N. Y.

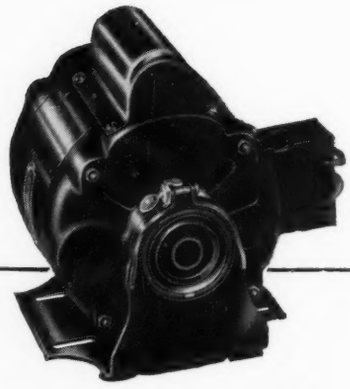
Quality-Controlled

Complete test and inspection routine covers; Chemical Analysis; Tensile and Torsional Strength; Ductility; Shock Resistance under Tension and Shear; Hardness; Head diameter, height and concentricity; Socket shape, size, depth and centricality; Thread fit. Every detail is checked!

PARKER-KALON
Quality-Controlled
SOCKET SCREWS

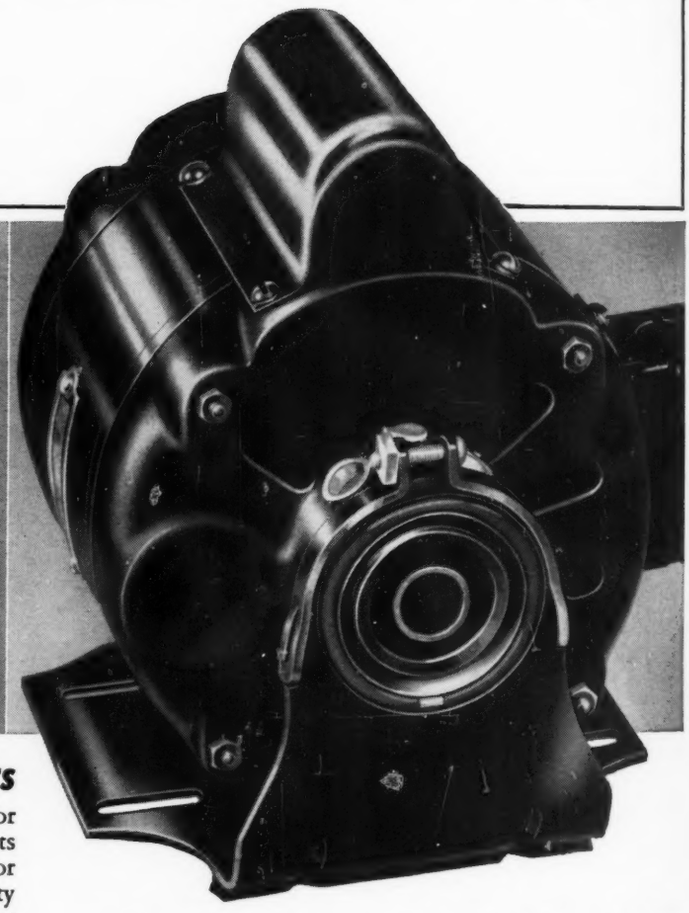
Give the Green Light to War Assemblies

THROW YOUR SCRAP INTO THE FIGHT!
VICTORY
ON EVERY FRONT
CONTINENTAL
CHICAGO · PITTSBURGH
ROLLS
ROLLING MILL EQUIPMENT
SPECIAL MACHINERY



When You Use Smaller Motors

You Can Still Have Your MARGIN of Safety



. . . use motors with Klixon Protectors

When using smaller motors, to conserve vital materials for your government, you don't have to worry about burnouts *if your motors have built-in Klixon Protectors.* For if a motor has a built-in Klixon Protector, you can run at peak capacity with safety. You can carry overloads safely. But the instant you overload it too much and it gets too hot, the Klixon Protector automatically cuts the motor off the line, thereby preventing damage or a complete burnout.

And while speaking of savings, just think of how much these built-in Klixon Protectors actually do save—the vital materials that go up in smoke when a motor burns out; the cost, time and materials necessary for rewindings; the lost production of idle machines; and the delay and red tape in getting motor replacements.

When buying motors—A. C. all sizes and D. C. up to 30 volts—insist on built-in Klixon Protectors.

Spencer Thermostat Co., 1112 Forest St., Attleboro, Mass.

KLIXON

TRADE MARK REG. U.S. PAT. OFF.

PRODUCTION MEN *prefer* DE LAVAL

1. De Laval Worm Gear drive gives even and constant transmission, without slipping, vibration or noise.

2. It is unaffected by grit, dust or moisture, and requires no readjustments for wear or stretch or for changes in atmospheric conditions.

3. It requires practically no attention.

4. It offers the greatest flexibility in the location of the motor and is the most compact of all drives.

5. It creates no fire or personal accident hazard.

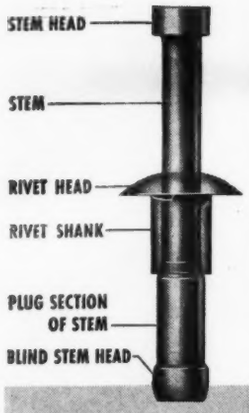
6. It is highly efficient, improves with use, and has an almost unlimited life.

7. It is available in a wide range of horsepowers, standardized center distances and ratios.

• • •

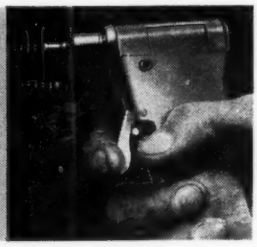
In all principal cities there are experienced De Laval engineers who will give you immediate and competent advice in the solution of drive problems. Ask for Publication W-1131.

DE LAVAL WORM GEAR DIVISION
of the De Laval Steam Turbine Co., Trenton, N. J.



THE STEM DOES THE WORK IN A CHERRY BLIND RIVET

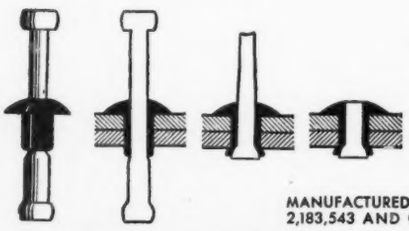
Positive head formation and shank expansion produced by rivet stem. No bucking bar needed



The Cherry Rivet is designed to do a first class riveting job in the blind or hard-to-get-at places in aircraft structures. This rivet is actually an assembly, consisting of a standard aircraft rivet which has been drilled and through which passes an aluminum alloy mandril or stem.

SPECIAL GUNS USED—The rivet can be placed in the work first or the projecting stem can be placed in the gun head and then inserted in the work. The gun may be either a hand-operated or power tool. (Head of the G-15 Pneumatic Gun is shown above.) In either case the gun pulls on the stem and pushes on the rivet head. As the stem is pulled through the rivet it forms a tulip head on the blind side, expands the shank of the rivet and permanently plugs the rivet. The pull continues until the stem breaks and frees the gun. The stem is trimmed flush with flat ground nippers.

FAST OPERATION—Cherry Rivets can be applied at the rate of 800 to 1600 per hour depending upon the type of rivet used. They give satisfactory performance with reasonable tolerances in grip length and hole size. Complete instruction on Cherry Rivets and their application will be furnished on request.



Mandril in the self-plugging Cherry Rivet, when pulled by special gun, forms a tulip head, expands rivet shank, permanently plugs the rivet and then breaks, releasing gun. The mandril is trimmed.

MANUFACTURED UNDER U. S. PATENT NO. 2,183,543 AND OTHER PATENTS PENDING

Cherry Rivet Company

LOS ANGELES, CALIFORNIA

Making a CENTRIFUGAL CASTING Better

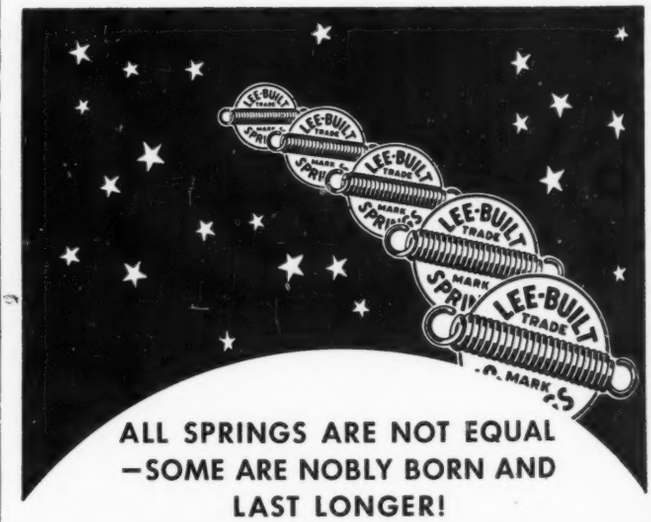
Accurate machining on modern equipment has helped to establish Shenango-Penn's reputation for *good* castings. They are clean, true to size and can be depended upon for close tolerances. Standard alloys have been established to conform with government and society specifications. Write for Booklet No. 141 covering properties and specifications.

ALL BRONZES • ALLOY IRONS

SHENANGO-PENN MOLD COMPANY

1203 W. THIRD ST., DOVER, OHIO

***Executive Offices:* Pittsburgh, Pa.**



ALL SPRINGS ARE NOT EQUAL —SOME ARE NOBLY BORN AND LAST LONGER!

LEE *Quality Springs*

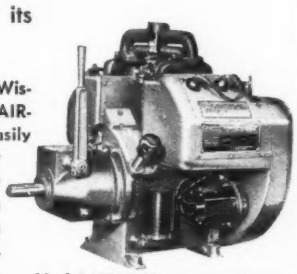
LEE SPRING COMPANY, Inc.

30 MAIN STREET BROOKLYN, N.Y.

NO Winter FREEZE-UPS

Even though duly delegated manpower may have instructions to provide against power equipment damage or slowdowns resulting from cold weather . . . the human equation can't always be depended upon to make good on its responsibilities.

There is nothing to freeze in a Wisconsin heavy-duty air-cooled engine. AIR-COOLING, and the ability to start easily in any weather . . . to run *continuously* under a full working load, on any kind of job within its power range . . . these are factors that logically make Wisconsin Engines the preferred year-round power.



Model VE-4 V-type 4 cyl. engine. Other types and sizes, 1 and 4 cyl. 1 to 35 hp.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation

MILWAUKEE, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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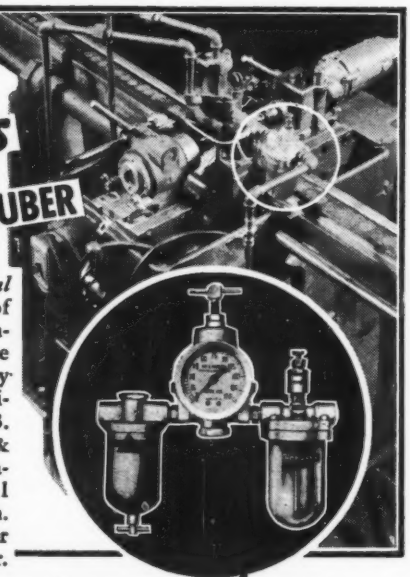
2 STRIKES on SCHICKELGRUBER



Both *chip removal* and *lubrication* of drill and countersink are done automatically by Norgren Lubricators on S. B. Whistler Drill & Countersink Machines in vital plane production. *More holes* . . . per drill and per hour.

NORGREN *Lubro-Control* UNITS

. . . in a wide variety of sizes and combinations to meet any requirement.

NORGREN (air-borne) LUBRICATION improves performance and licks wear and corrosion in air tools and production machines wherever air is used.

C. A. NORGREN Denver, Colorado CATALOG 400

HAVE YOU A CRITICAL NON-FERROUS METAL PROBLEM?

TWO MONTHS AGO

JOHN—OUR PRODUCTION MUST BE INCREASED. WE MUST GET MORE METAL — AND I HAVE AN IDEA.
OK FELLA—BUT HOW ARE YOU GOING TO GET A LARGER ALLOCATION OF THE NON-FERROUS METALS WE'RE USING?

HERE'S ONE SOLUTION THAT IS SUCCESSFULLY MEETING REQUIREMENTS

- - TODAY

BILL — YOU HAVE DONE A SWELL JOB — OUR PRODUCTION IS UP SUBSTANTIALLY AND I'LL ADMIT I NEVER THOUGHT STEEL WOULD SERVE AS WELL AS OTHER METAL ON THIS JOB.
THIS IS A SPECIALTY STEEL— CMP PRECISION COLD ROLLED STRIP! THEY WORKED WITH US UNTIL THE ESSENTIAL MATERIAL CHARACTERISTICS WERE MET.

VERSATILITY — ANOTHER CMP PRECISION STRIP ADVANTAGE

How can you use CMP cold rolled strip steel to replace critical light gauge non-ferrous metals? Yes — that was the challenge. And for important war equipment parts it has been achieved with remarkable success.

By making a wide range of physical properties available to meet the essential service characteristics desired, CMP light gauge strip offers broad adaptability. CMP precision rolling for unusual close tolerances and the precise control of uniformity for consistent duplication provides a metal that assures trouble-free fabrication for low cost top production results. It's worth investigating now for your vital war production and good to have the facts for your postwar plans. Write today or phone Youngstown 4-3184 for immediate information.

CMP PRECISION COLD ROLLED STRIP STEEL

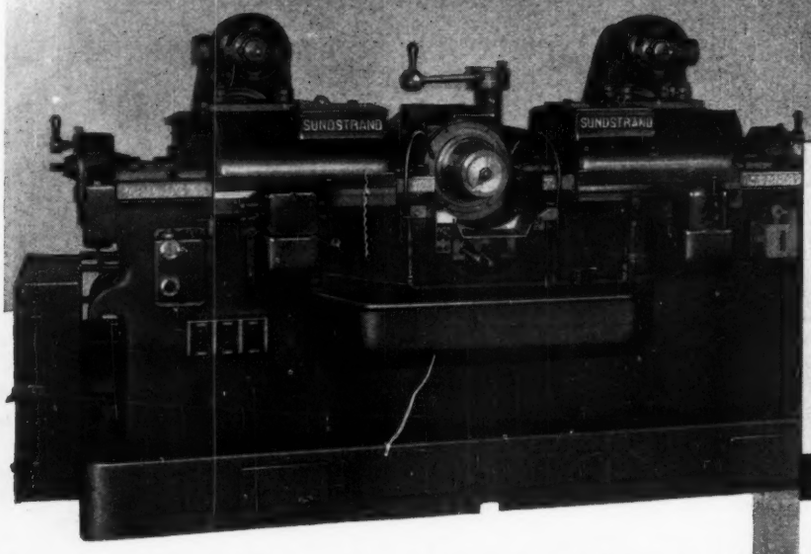
LET'S ALL HELP TODAY

Get in the Scrap!

THE COLD METAL PRODUCTS CO.

Subsidiary of The Cold Metal Process Co., Youngstown, O.

Simplify Designing . . . Speed Production
Use SUNDSTRAND Hydraulic Units



Special Cam Miller for Aircraft Industry Has SUNDSTRAND Hydraulic Equipment

Sundstrand Hydraulic Equipment simplifies design, layout and construction of machine tools, and general industrial applications. It saves time, work and worry; promotes easy operation and high output in finished machines. It is especially useful in creating new machine tools, and other equipment, for special purposes.

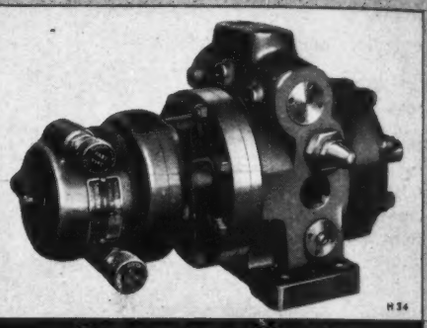
These Sundstrand advantages are demonstrated by the special cam milling machine, illustrated, in which Sundstrand Pumping Units supply oil power for Sundstrand Fluid Motors that actuate the spindle slides and work-carrier.

Use of Sundstrand Hydraulic Equipment gives the designer ease and freedom in establishing automatic movements, cycles, stops and safeguards; provides climb cutting as well as conventional milling. Sundstrand Hydraulic Units give stepless adjustments of speeds and feeds throughout wide ranges. This simplifies design, and saves time by eliminating calculations of progressions and gear-ratios. Sundstrand Tank Units are ideal for easy accessible installation. Sundstrand Fluid Motors make simple, direct, effective application of power.

Layout is easier and faster; it is only necessary to block in outlines of Sundstrand Units, and to indicate pipe lines. Much mechanical complication, and detailing, is saved.

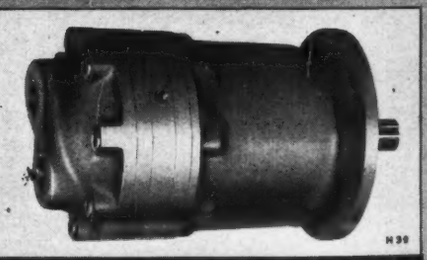
Finished machines come out of the shop fast when Sundstrand Hydraulic Equipment is used; it is easy to install, connect, time, and test. In service, these machines speed up production, save skilled labor, reduce operator training and fatigue, meet modern requirements.

The advantages and applications of Sundstrand Hydraulic Equipment are practically unlimited. Investigate, *today.*



Pumping Units

Sundstrand Pumping Units are made in two types. PWX, illustrated, contains control valves; and provides one, two, or three adjustable feed rates, with rapid traverse. PWX Units can have an additional constant displacement pump to supply pressure for hydraulic fixtures, or work-clamping, if desired. WX Pumping Units supply clamping pressure only. Sundstrand Tank Units contain an oil reservoir, one or more Pumping Units, Control Valves in suitable arrangements, and provision for exterior mounting of electric driving motor.



Oil Power Fluid Motors

Sundstrand Oil Power Fluid Motors are listed in ten sizes, ranging from 1 h.p. to 40 h.p. normal rating. Eight of these may have either constant or variable displacement. The remaining two are "torque" motors especially suitable for actuating machine tool slides in feed and rapid traverse.

Controls

Sundstrand Hydraulic Control Valves, Solenoid Valves and Accessories are available for hydraulic circuits and arrangements to meet any practical operating condition or requirement.

Sundstrand Pump Division

2556 Eleventh Street, Rockford, Illinois, U. S. A.

HELPFUL LITERATURE

for DESIGN EXECUTIVES

1. Motor Starters

Allen-Bradley Co.—Illustrated bulletin No. 640 describes semi-automatic resistance starters for manually starting polyphase squirrel cage motors. These controls are designed for loads which must be accelerated rapidly, or for applications where starting currents must be kept low to prevent lamp flicker.

2. Malleable Castings

Lake City Malleable Co.—12-page illustrated booklet, "Fighting Men—Critical Materials," shows some typical conversions which have been effected using malleable castings to replace aluminum, zinc die castings, steel castings, steel stampings, welded assemblies and grey iron castings.

3. Electric Equipment

Colt's Patent Fire Arms Manufacturing Co.—Illustrated "Coltalog" contains quick reference listing of all company's equipment. Included are data on all types of alternating and direct current switches, as well as other industrial control equipment.

4. Pump Equipment

Esty Pump Co., Inc. — Single-page illustrated folder describes model C pump. Unit is S.A.E. standard base mounted. Ports are tapped for ¾-inch pipe thread. Capacity is 3 to 12 gallons per minute at three hundred to 12 hundred revolutions per minute. There are only three moving parts and may be removed without disturbing mounting of pump.

5. V-Belt Drives

Multiple V-Belt Drive Association—16-page illustrated bulletin, "23 Ways to Conserve the Life of Your Multiple V-Belt Drives," provide check-list and suggestions on cause of excessive wear and corrections to be effected. Factors such as under-belting, proper installation and replacement, and belt care are discussed.

6. Variable Speed Drives

Reeves Pulley Co.—4-page illustrated broadside, "How Reeves Helps Sharpen the Eagle's Claws," describes variable speed transmissions, variable speed motor pulleys, and "Vari-Speed Motodrive" units. Typical applications of these drives to machines engaged in war production operations are shown.

7. Motor Care

Century Electric Co.—4-page illustrated bulletin No. 21-161 discusses installation, care and adjustment of squirrel cage induction polyphase motors in sizes ranging from 1/6 to 400 horsepower. Step-by-step instruction is given in various phases of motor operation. Typical wiring diagrams are included.

8. Fastening Devices

National Screw & Manufacturing Co.—228-page illustrated catalog No. 42-A gives specifications and list prices on complete line of bolts, screws, nuts, rivets and tacks. Section on technical data includes decimal equivalents, wire gage sizes, pitch diameters, tap drill sizes, heat treating and other information.

9. Parts Refrigerator

Avery Engineering Co.—4-page illustrated bulletin on the "Revco Sub-zero Chest" explains features and applications of this refrigerating unit which is designed for new sub-zero industrial technique as applied to war industries. Uniform temperatures of as low as minus 50 degrees Fahr. can be obtained with both portable and heavy duty models.

10. Ceramics

United States Stoneware Co.—12-page illustrated bulletin D briefly describes complete line of synthetic, ceramic and alloy materials which have been developed for use in process equipment to combat corrosion. "Tygon" resins for various process applications are discussed, as are rubber, synthetics, alloys, lead and chemical stoneware.

11. Electric Brakes

Empire Electric Brake Co.—18-page illustrated manual is descriptive of "Magdraulic" electric brakes for automotive vehicles and industrial machinery. Design and operation of these units in various sizes and styles are covered. Engineering drawings show construction and other details of available standard types.

12. Laminated Plastic

National Vulcanized Fibre Co.—44-page illustrated handbook on "Phenolite Laminated Bakelite" contains technical and descriptive data for design and engineering applications. General properties, specifications, available forms, fabrication, machining and typical applications are covered.

13. Self-Tapping Screws

Parker-Kalon Corp.—20-page illustrated booklet No. 475 is miniature catalog on self-tapping screws. Advantages of each type of screw; stock sizes and head styles; packing, finishes and special screws are described. Typical applications of all types of self-tapping screws are shown.

14. Bearing Lubrication

SKF Industries, Inc.—28-page illustrated, "Guide to Better Bearing Lubrication," contains designs, formulas and graphs which explain technical text. Subjects treated include function of lubrication, oil lubrication, recommended viscosities, oil supply systems, grease lubrication, lubricant supply systems, fittings and protection against moisture.

15. Enclosed Motor

General Electric Co.—2-page illustrated bulletin No. GEA-3922 is descriptive of line of totally enclosed induction motors designed for use in magnesium, aluminum and other combustible metal dust conditions. Sizes range from 1 to 125 horsepower, and motors are listed and labeled by Underwriters' Laboratories, Inc., for class II, group G locations.

MACHINE DESIGN
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Cleveland, Ohio

12-42

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HELPFUL LITERATURE

16. Rubber & Synthetics

B. F. Goodrich Co.—30-page illustrated "Rubber Guide Book for American War Industries" lists applications and properties of many types of natural, synthetic and reclaimed rubber materials for industrial and aeronautical purposes. Complete data are given on "Ameripol," hydraulic parts, sponge products, industrial gloves, extruded goods, anode covering, hard rubber parts, rubber cement and lathe cut goods.

17. Electric Equipment

Federal Electric Products Co.—68-page illustrated catalog No. 42 contains engineering information on safety switches, panelboards, circuit breakers and other electrical equipment. Various units are described and typical installations shown. Complete data are included to aid in selection of proper wiring and switches for various sizes and types of motors.

18. Motor Generators

Carter Motor Co.—12-page illustrated catalog No. 100 presents full details on line of permanent magnet motor-generators, hand generators and converters. Smallest size "Dynamotor" is rated at 100 watts and weighs only 4¾ pounds. This equipment is especially engineered for radio communication applications. Design and features of various sizes are explained.

19. Machining Aluminum

Aluminum Co. of America—44-page illustrated booklet, "Machining Alcoa Aluminum," sets forth general principles of machining aluminum and its alloys; suggests speeds, feeds and depths of cuts which will produce satisfactory results; points out where practices and tools common to other metals may be used; and indicates where special tools or practices are desirable.

20. Electric Motors

Allis-Chalmers Manufacturing Co.—12-page illustrated bulletin No. B6052-G gives pertinent factors necessary for selecting correct motors for wartime applications. Compact, simplified charts show electrical and mechanical characteristics of various motor types. Rating, duty, torques, starting current, efficiency and slip are indicated for squirrel cage, wound rotor, direct current and synchronous motors.

21. Babbitt Metal

National Bearing Metals Corp.—4-page illustrated folder on "Rex" babbitt metal gives characteristics of this low tin alloy which has been developed as replacement for high tin base babbitts for the duration.

22. Aluminum Bronzes

Ampco Metal, Inc.—8-page illustrated bulletin, "How Aircraft Designing Engineers Use Ampco Metal," describes pictorially use of these bronze alloys by aircraft industry. Applications in aircraft engines propeller assemblies, landing gears, windshield wipers and other parts are shown.

23. Air Motors

Smith-Johnson Corp. — 4-page illustrated bulletin on "Senacon" model AM air motors shows typical applications of these air driven, double acting, reciprocating power motors. Operating on any air pressure up to 175 pounds per square inch, units have stroke lengths ranging from 1 to 18 inches. All have 2½-inch piston diameters.

24. Relays

C. P. Clare & Co.—20-page illustrated catalog, "Relays," lists features, construction details and available materials in complete line of electrical relays for industrial, electronic, radio, signal and control applications. Specifications are given for standard, plug-in and special relays, as well as electric counters, contact assemblies, coils, switches and other accessories.

25. Electric Heating Units

Westinghouse Electric & Manufacturing Co.—38-page illustrated catalog No. 28-000 describes electric heating units and controls for industrial applications involving heating of liquids, solids or air. Specifications, ratings and prices are given on such equipment as strip heaters, cartridge heaters, immersion heaters, melting pots and oven heaters, as well as thermostats, switches and contactors.

26. Photoelectric Cells

Emby Products Co.—8-page illustrated bulletin comprises technical data and electrical characteristics of line of blocking layer photoelectric cells. This device does not require any outside power source and delivers photo current of over 450 microamperes per lumen. Applications of these units are described.

27. Hydraulic Equipment

Fleetwings, Inc.—30-page illustrated catalog, "Hydraulic Equipment," shows design and application features of line of hydraulic selector valves which assure trouble-free operation throughout temperature range from minus 40 up to 200 degrees Fahr. Wear has been practically eliminated in these piston type valves which may be used in conjunction with all types of hydraulic equipment.

28. Plastic Tubing

Elmer E. Mills Corp. — 6-page illustrated broadside, "Mills Plastic," discusses technical data and physical properties of "Saran" plastic tubing and fittings. Fabricating characteristics, general properties, thermal properties, electrical properties and effect of reagents are listed. Bursting and working pressures versus temperature are charted for tubing ranging in diameter from ½ to ⅜ inch.

29. Gummed Labels

Ever Ready Label Corp. — Two illustrated sheets show typical labels for use in planning, purchasing, designing, production and shipping applications. Production labels are illustrated in full color. Also described are printed labels which stick to metal and may be used for inspection data, instructions and warnings.

30. High Speed Steel

Jessop Steel Co. — 10-page illustrated catalog, "Mogul", describes molybdenum-tungsten high speed steel. Features are low hardening temperature, high cutting ability, low cost and wide application. Catalog includes physical properties and analysis of steel. Typical applications are listed and carbon range for each is included. Forms available are bars, rounds, squares, octagons, flats, and special shapes.

31. Synthetic Rubber

Thiokol Corp. — 10-page illustrated catalog, Vol. 2, No. 3, describes use of Thiokol as applied for retreading tires. Benefits and mass application and facts on supply as they are seen today are discussed. Applications of this synthetic rubber are gaskets for tanks, hose, tires and as liner for box cars. Catalog gives general description and processing problems.

32. Porcelain Enamel

American Rolling Mill Co.—24-page illustrated booklet, "Porcelain Enamel, a non-critical finish for wartime uses," describes properties and applications of this finish. Useful engineering data are included, with particular emphasis on designing for use of porcelain enamel.

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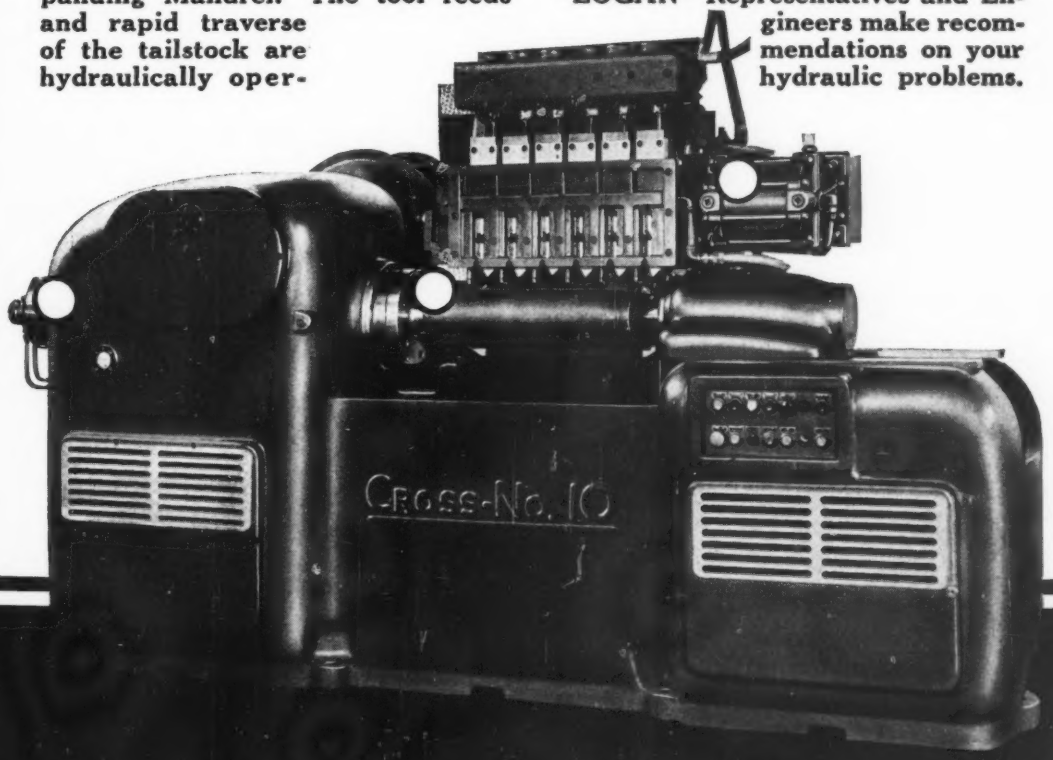

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NEW MACHINES—

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(For illustrations of other outstanding machinery, see Pages 116-117)

Air Conditioning

Air circulator for ultra-violet lamps, Reynolds Electric Co., Chicago.
*Condensing unit, Chrysler Corp., Airtemp Div., Dayton, O.

Armament

Shell sprayer, Eclipse Air Brush Co., Newark, N. J.
Teardown washer for engines, Industrial Washing Machine Corp., New Brunswick, N. J.
Shot tip polishing machine, Leiman Bros., Newark, N. J.
Hydraulic release shell truck, Lewis Shepard Sales Corp., Watertown, Mass.

Finishing

Dipping machine, The Black Rock Mfg. Co., Bridgeport, Conn.

Heat Treating

Hydraulic machine for flame hardening, Hydraulic Machinery Inc., Detroit.
Aluminum heat-treating furnace, Despatch Oven Co., Minneapolis.

Industrial

Exhauster and ventilator, Chelsea Fan & Blower Co., Irvington, N. J.
Employe identification camera unit, Charles Mayer Studios, Akron, O.

Instruments

Moisture measuring unit, Moisture Regulator Co., Los Angeles.
Moisture tester for dehydrated foods, Colloid Equipment Co. Inc., New York.
Radiographic and diffraction unit for inspecting castings, Kelly-Koett Mfg. Co., Covington, Ky.
Dynamic balancing machine, Bear Mfg. Co., Industrial Div., Rock Island, Ill.

Materials Handling

Heavy-duty tractor, Crescent Truck Co., Lebanon, Pa.
Box carrier, Cleveland Tramrail Div., Cleveland Crane & Engrg. Co., Wickliffe, O.

*Illustrated in pictorial spread, Pages 116-117.

Metalworking

Double-end tool grinder, Willeys Carbide Tool Co., Detroit.
Combined horizontal boring mill and jib borer, DeVlieg Machine Co., Ferndale, Mich.
Hydraulic hot molding press, E. W. Bliss Co., Brooklyn.
*Vertical boring mill, Cincinnati Planer Co., Cincinnati.
*Precision tapping machine, Detroit Tap & Tool Co., Detroit.
*Inclinable press, E. W. Bliss Co., Brooklyn.
*Horizontal and vertical boring mill, Fray Machine Tool Co., Glendale, Calif.
*Horizontal hydraulic drawing press, Baldwin Southwark Div., Baldwin Locomotive Works, Philadelphia.
*Heavy-duty turret lathe, Warner & Swasey Co., Cleveland.
*Self-contained hydraulic metal drawing press, The Hydraulic Press Mfg. Co., Mt. Gilead, O.
Floor-type turret lathe, South Bend Lathe Works, South Bend, Ind.
Radial tapping machine, Bakewell Mfg. Co., Los Angeles.
Three-way horizontal drilling machine, Baker Bros., Toledo, O.
Supersensitive high-speed drill press, Edward Blake Co., Newton Centre, Mass.
External grinder, H. Leach Machinery Co., Providence, R. I.

Office

Interceptor phone system, Executone Inc., New York.
Intercommunicating unit, Talk-A-Phone Mfg. Co., Chicago.

Quarry

Brick and masonry saw, Clipper Mfg. Co., St. Louis.

Radio

Automatic frequency response recorder, Sound Apparatus Co., New York.

Refining

Transformer cooler, Allis-Chalmers Mfg. Co., Milwaukee.

Testing

Stratosphere chamber for aircraft parts testing, Kold-Hold Mfg. Co., Lansing, Mich.

Welding

Equipment for automatic arc welding with heavily-coated stick electrodes, General Electric Co., Schenectady.
Forge welder, Progressive Welder Co., Detroit.

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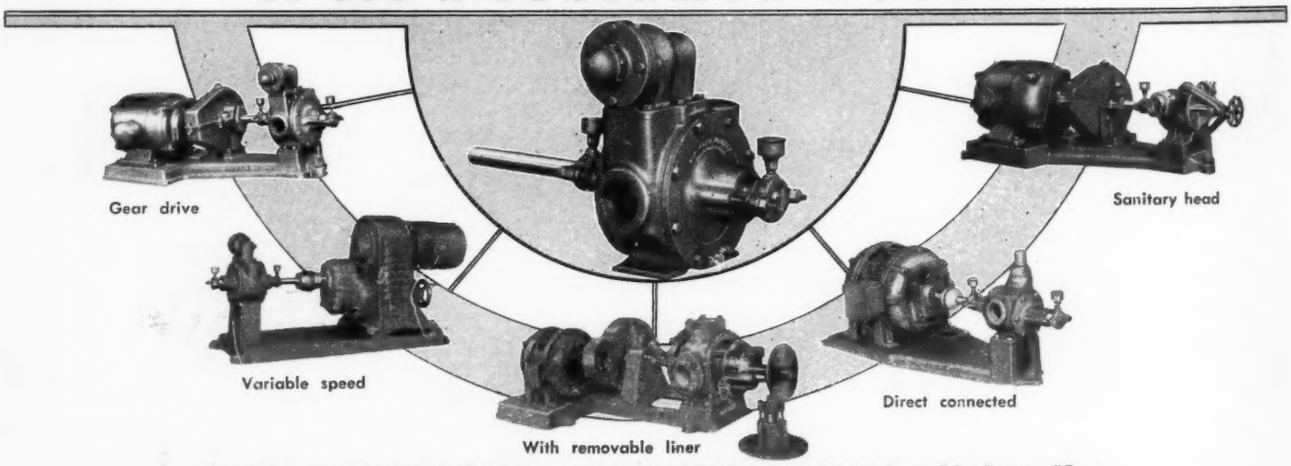

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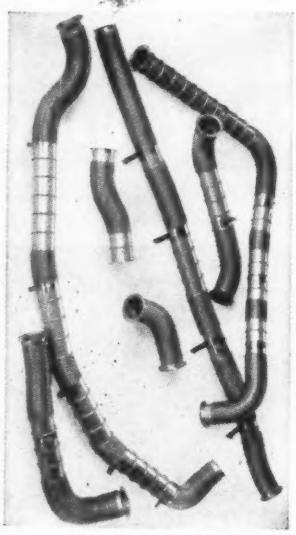

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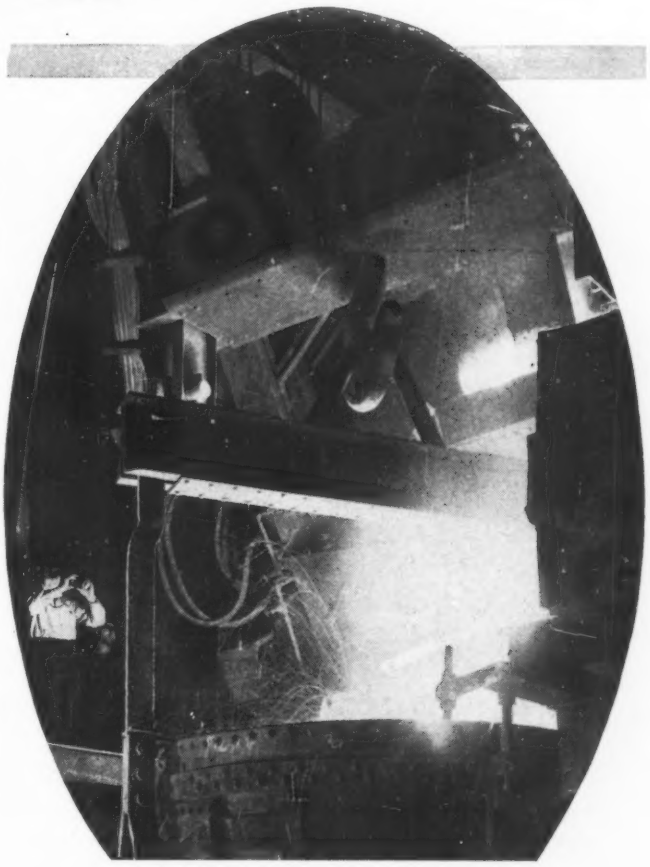

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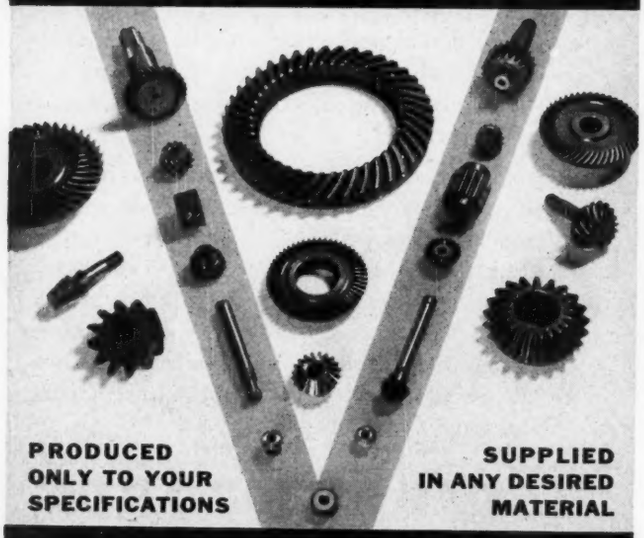

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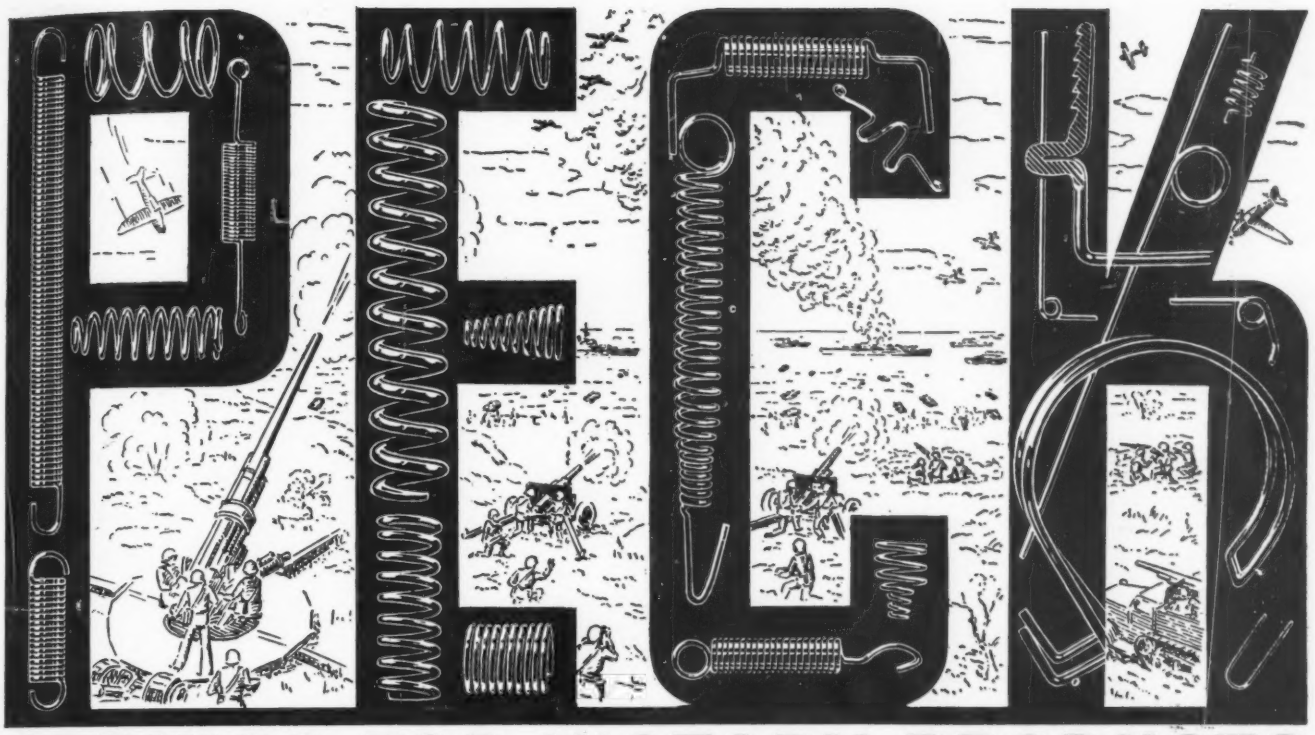

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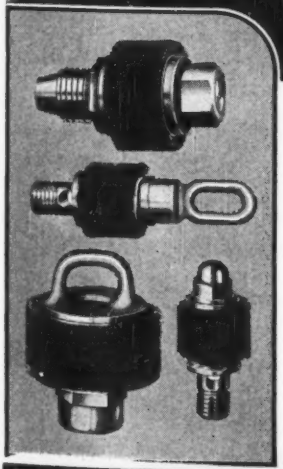

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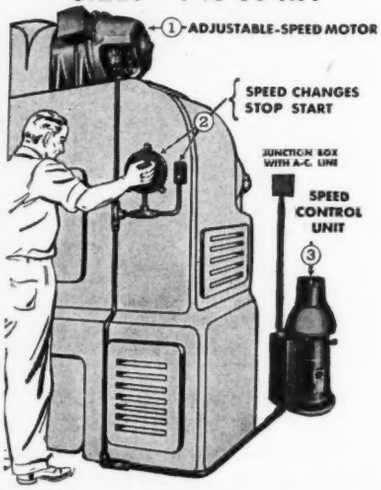

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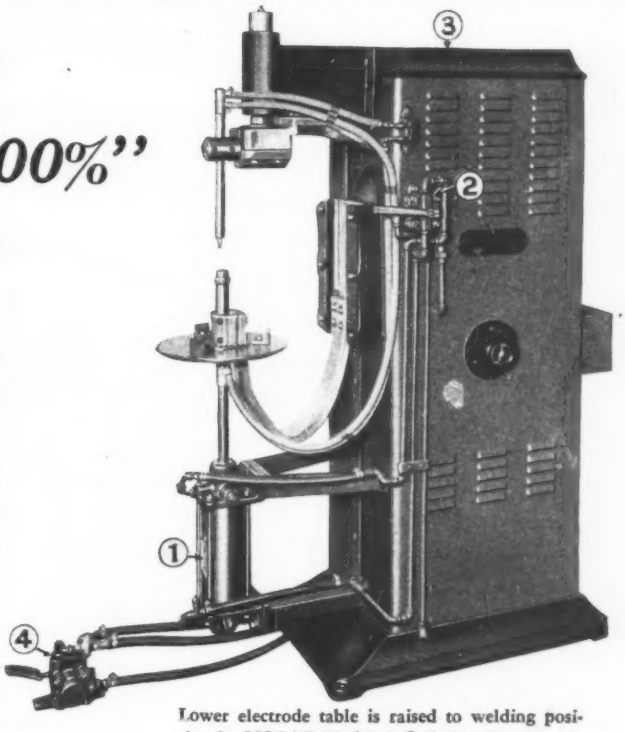

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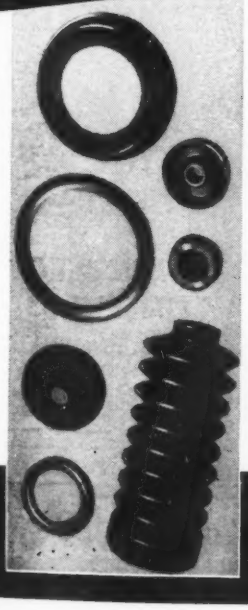

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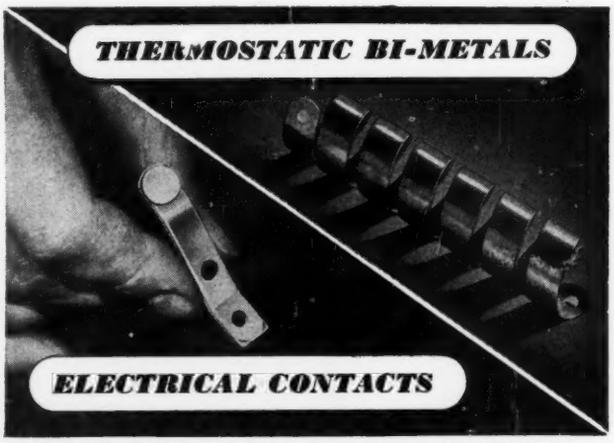

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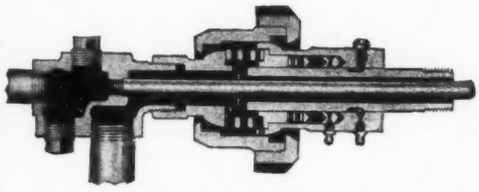

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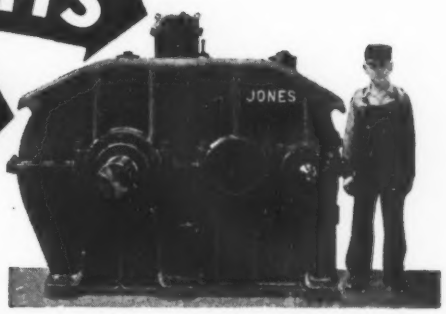

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All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Liberal stocks are carried to facilitate shipments.

Catalog No. 70 will save you time and effort in laying out drives that call for Herringbone gears.

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CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
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LOW TEMPERATURE WELDING

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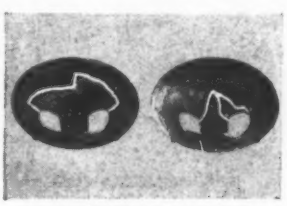
Use Castolin Eutectic Low Temperature welding alloys No. 14 and No. 24B* in place of "hard-to-get" bronze welding rods. Castolin Eutectic Alloys No. 14* and No. 24B* contain no scarce metals . . . available with priority A9.*



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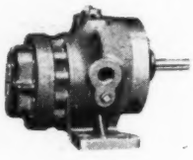
50% Saved — One customer writes: "So far the new Roper has proved the easiest of all to install. In fact, the last 6 Ropers installed saved 18 hours labor... about 3 hours on each." Other Roper users report savings of installation time up to 50%.

52% Saved — Roper *direct-drive* Pumps require only 48% as much floor space as other models . . . and in the many plants that are loaded to the guards with war production, space is priceless.

20% Saved — Roper *hydraulically balanced* Pumps reduce power consumption as much as 20% . . . a saving important to the Victory program as it releases the unneeded power for other vital operations.

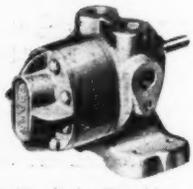
3 Series Of Pumps

Capacities from one to 1000 gallons per minute . . . pressures up to 1000 lbs. per square inch . . . speeds up to 1800 r.p.m. . . . 21 drives and mountings . . . 8 piping arrangements.



Handle Any Liquid

Any liquid free from abrasives can be pumped by a Roper. It makes no difference how thick or how thin the liquid is, a Roper will handle it economically and efficiently.



ROPER
Rotary Pumps

Write for Catalog 932. It contains a summary and a digest of valuable information on pumps and pumping problems.

GEO. D. ROPER CORP., ROCKFORD, ILL.

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It's a Natural for Plastics, John

...FILE IT FOR THE DURATION!"

WHY?

War work can postpone production of plastics parts, yes. But the planning, design and development, all the headwork that goes into getting your job squared off for production . . . ahead of the post-war rush . . . those things can be done today without detriment to war production. Even with your plant . . . and ours . . . roaring away on a non-stop, 24-hour-a-day schedule. Because there's the 25th hour . . .

That's the time the executive finds between administration problems . . . the lapse after the engineer passes the job along to production . . . the minutes that sales managers-turned-expediters discover between jobs. It's the time that can't, by your every effort, be legitimately devoted to your immediate part in the war . . . time that *can* be used for the important problems of peace.

Forward-looking companies that we know are using their 25th hours (and ours) for planning post-war design and development. We're lending them a hand . . . even with presses and toolrooms working 24 hours a day. When peace comes, they're going to have that much of a head-start on production. Are you . . . ?

Here, in the largest, best-equipped molding plant in the Middle West, we've earned a coast-to-coast reputation as a good place to come for molded plastics applications. For designing, mold-making, engineering and turning out finished parts . . . for complete, friendly, precision service. All this can be geared to your needs . . . our engineers will gladly explain.

CHICAGO MOLDED PROD. CORP.

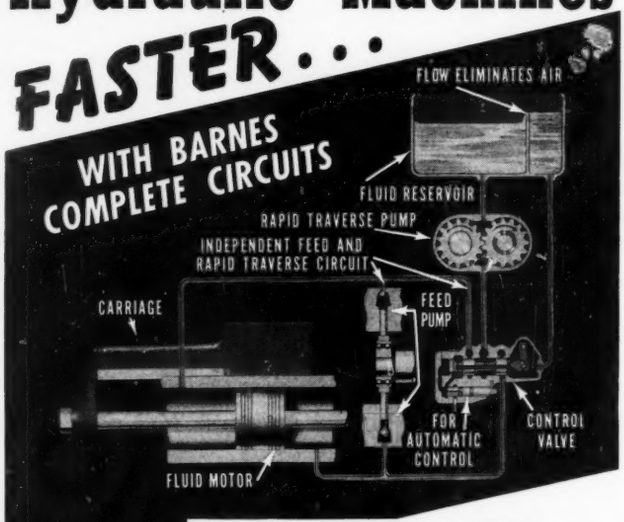
CHICAGO MOLDED PRODUCTS CORPORATION

Precision Plastic Molding

1028 NORTH KOLMAR AVENUE, CHICAGO, ILLINOIS

COMPRESSION, INJECTION, TRANSFER AND EXTRUSION MOLDING OF ALL PLASTIC MATERIALS

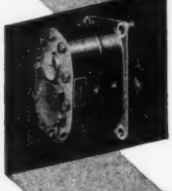
Design Better Hydraulic Machines FASTER...



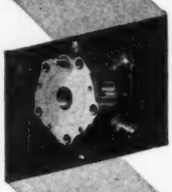
ONE SOURCE OF SUPPLY.... UNDIVIDED RESPONSIBILITY

The Barnes Unit-Type method of securing hydraulics for metal working machines and other mechanical structures offers one of the fastest and most efficient hydraulic design services available.

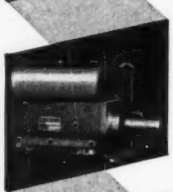
Complete special circuits are designed and built from Barnes standard hydraulic elements — pumps, valves, etc. These are assembled in compact self-contained or panel units simple to install — *SAVES DESIGN AND ASSEMBLY TIME, SPEEDS DELIVERY.* Here is a typical simple circuit designed from Barnes standard elements.



GEAR PUMPS used to supply a large volume of oil for traversing machine members. Suitable for pressures up to 1000 lbs. per square inch.



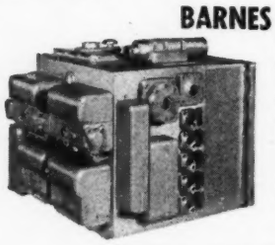
PISTON PUMPS used to supply a small measured amount of oil at pressures up to 2000 lbs. per square inch — provides a smooth and precise feed.



CONTROL VALVES— A complete line of Barnes valves are available for use in Barnes circuits . . . with manual or automatic control, or both, and suitable for volumes up to 25 gallons per minute.

OIL RESERVOIRS— Complete circuits furnished with reservoir . . . or as panel units for mounting on tank of your design.

BARNES ***COMPLETE SELF-CONTAINED HYDRAULIC UNIT***



Contains all necessary pumps and valves to complete hydraulic functions of your machine. Furnished complete with cylinders. You merely connect two pipes to each cylinder of machine to complete the hydraulic installation.

FREE DATA

40 page booklet contains detail descriptions of all Barnes elements and typical installation circuits. Write for your copy today. Ask for Bulletin M.D. 1242.

John S. Barnes Corporation

DETROIT SALES OFFICE
503 NEW CENTER BLDG.
TR-1-1706

MAIN OFFICE AND FACTORY
ROCKFORD, ILL.

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UNITCASTINGS

RESIST *EXTREMES*

OF HEAT, COLD, PRESSURE!

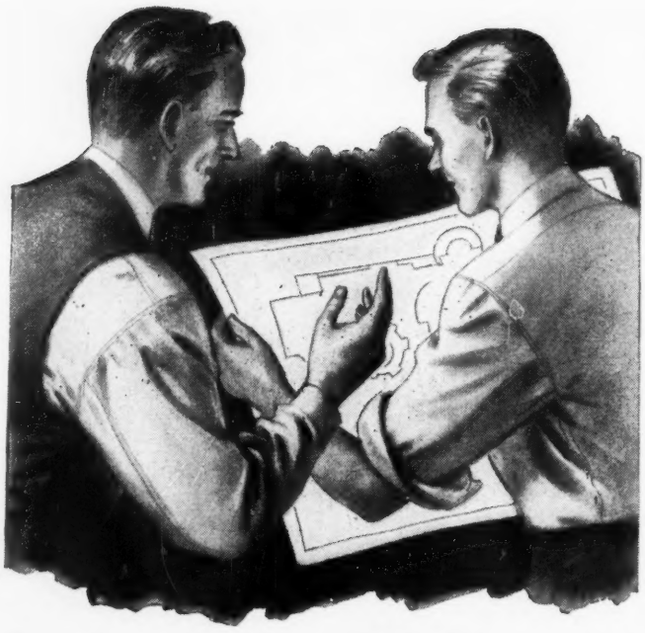
★ More and more vital parts today for tanks, planes, guns and ships are *Unitcastings!* And because of the job they're doing now... steel castings will be used more than ever after the war!

On battle fronts everywhere today, these modern steel castings *stand the gaff*... defying the forces that are constantly working to destroy metal... extremes of heat, cold, pressure, strain and abrasion.

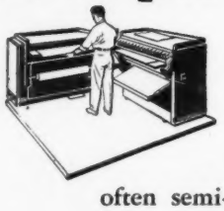
Both in research and under front-line fire ...results show that Unitcastings are the *right answer* for rugged dependability, streamlined design, precision, close tolerances, rigidity and economy. Concerning today's priority jobs... or plans for peacetime tomorrow... talk it over with Unitcast! Call or write Unitcast Corporation, Toledo, Ohio.

UNITCAST CORPORATION

ALLOY AND CARBON ELECTRIC STEEL CASTINGS



Help these NEW men with *easier-reading* BW prints



SKILLED engineers are working under pressure to plan new machines—new parts. Yet those who must execute those plans in the shop are often semi-skilled and unskilled employees to whom old-fashioned blue prints are confusing. Help these new men to avoid errors and delay with Bruning Black and White (black line) Prints. The sharp black lines on white backgrounds are far easier to read—the white backgrounds make checking simple. No wonder so many plants prefer BW prints for shop use!

Remember, too: Bruning BW prints are produced *faster* than blue prints . . . need no washing or drying . . . can be made instantly in large quantities on sheets cut to the exact size of your tracings. Get the facts about Bruning BW—a free booklet is yours for the asking. Charles Bruning Company, Inc. 2105-257

BRUNING

Since 1897

NEW YORK • CHICAGO • LOS ANGELES

Branches in 14 Principal Cities

SPEEDS—SIMPLIFIES—AND PROTECTS A NATION'S DRAFTING

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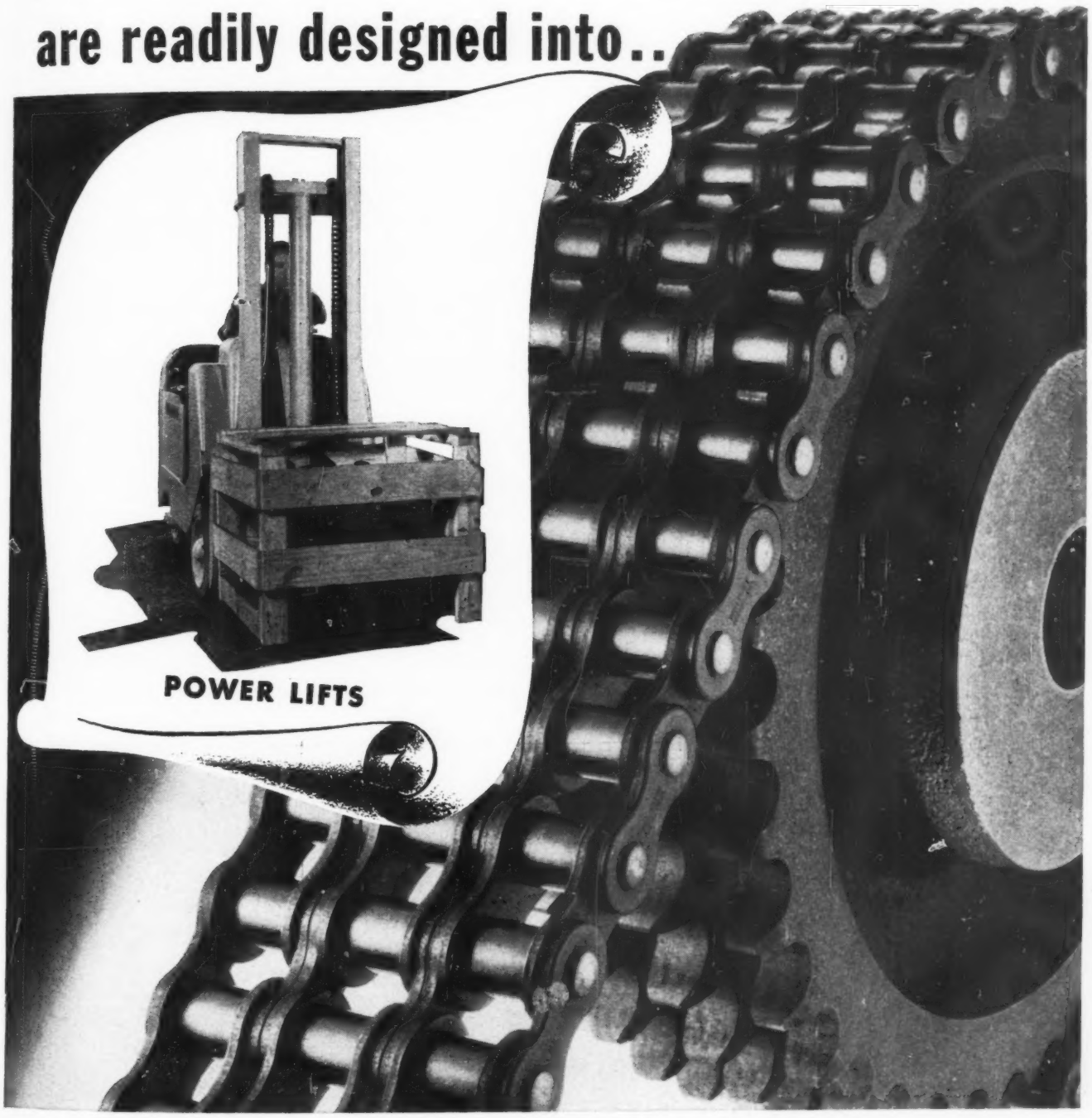
WHITNEY CHAINS

are readily designed into..



WHITNEY ROLLER CHAINS are adaptable to many fields of service. They have the advanced design, the balanced construction . . . plus more than will ever be needed of plain brute strength, as the photo shows . . . to handle the toughest power-drive jobs. Then they serve, too, as "common carriers" in Whitney Platform Chains and other types of conveyor chains, with special attachments as needed. But in whichever field your own design-problems lie, you can have the advantages of Whitney Roller Chains engineered specially to your own needs on high-rated war work.

THE WHITNEY CHAIN AND MANUFACTURING COMPANY, HARTFORD, CONNECTICUT

It Takes a Beach-Head to Start an Invasion

This welded steel amphibian tractor is the Marines' answer to tough "competition" that beat us to the offensive, then dug in.

ALTER EGO: Those few Marines may not win the war by themselves, but they will establish a beach-head and that's a mighty vital prelude to dislodging Axis "competition".

Yes, war is like that. Business now is somewhat like that. Business after the war will be just like that!

ALTER EGO: Right. To win the Battle for Business after this war we're going to have to get on the offensive with welded steel products.

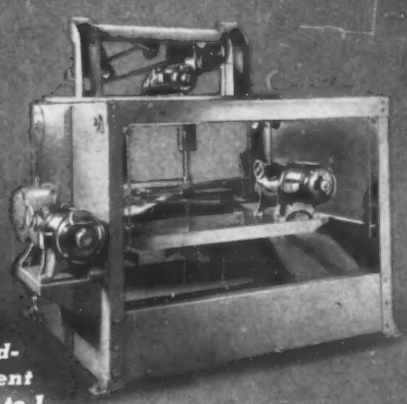
Right. But first we must establish our beach-heads of welding knowledge. Let's start this prelude to invasion of the post-war market NOW.

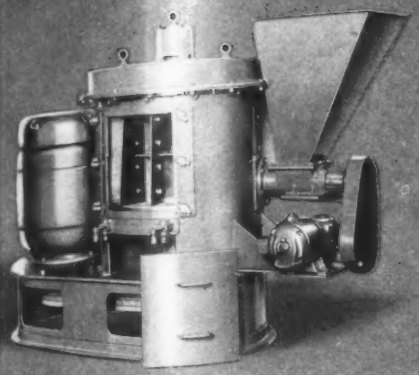
Ask your inner self if a "beach-head" of welding knowledge shouldn't precede post-war market invasion.

THE LINCOLN ELECTRIC COMPANY
CLEVELAND, OHIO

then I said to myself—

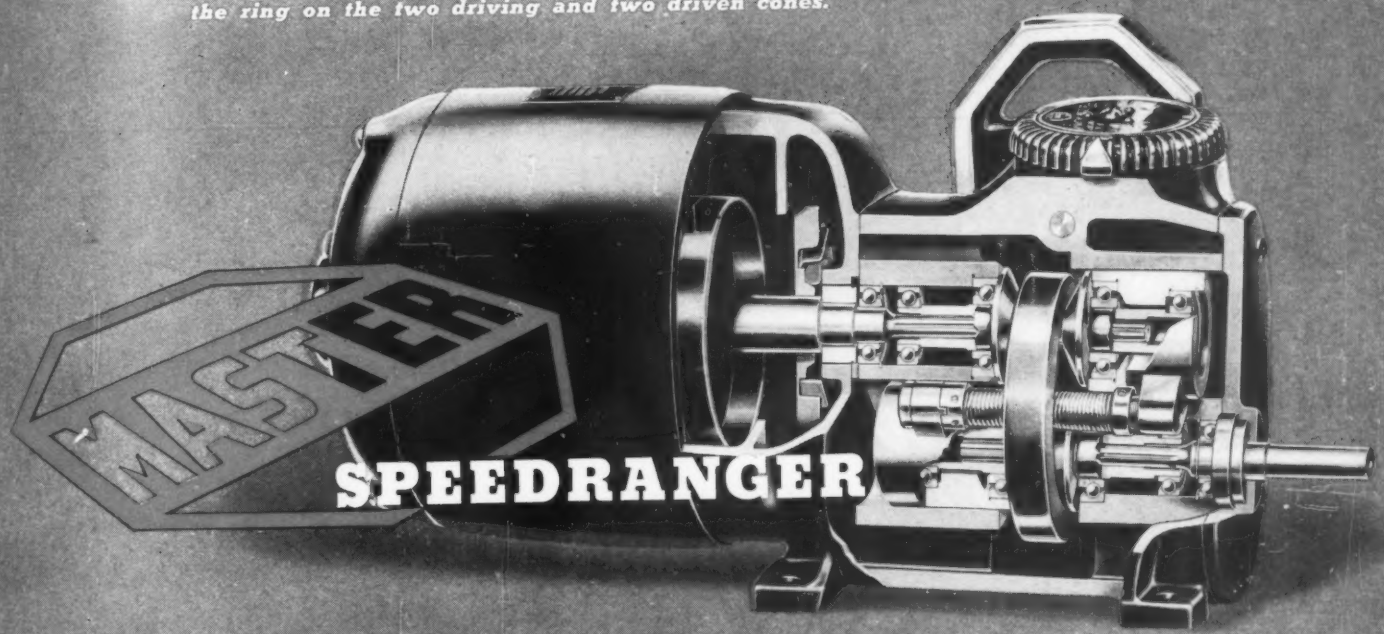
MARINES and WELDING
—the situation will be well in hand



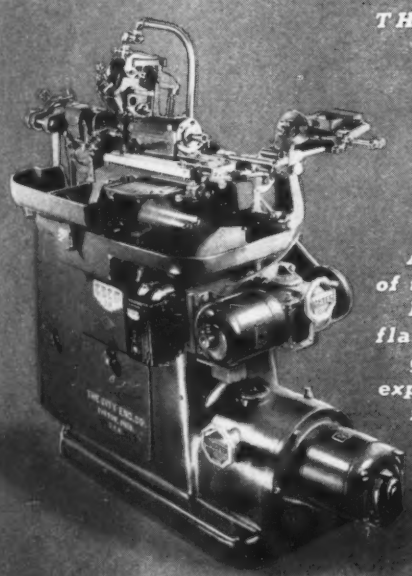


Available in sizes up to and including 3 horsepower in three different speed ranges—3 to 1, 6 to 1 and 9 to 1. Only with an all-metal drive can you secure the compactness, simplicity, flexibility and economy that are so advantageous today.

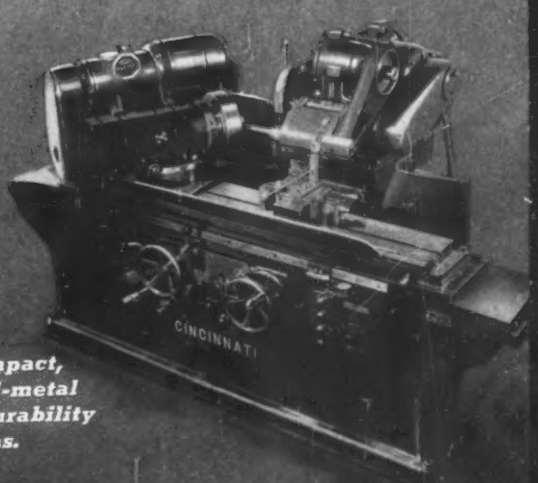
Infinitely variable speed may be secured to any R. P. M. within the range of the unit. The output speed is increased or decreased by variation of the position of the ring on the two driving and two driven cones.



THE MASTER ELECTRIC COMPANY · DAYTON, OHIO



Available in the vast number of types that make up the Master line including the flanged type as shown, also gearhead, unibrake, fan-cooled, explosion-proof, splash-proof, multi-speed, etc.



Save material and save space with the simple, compact, integrally built Master Speedranger. The all-metal construction insures greatest possible durability and freedom from service interruptions.

The more Timken Bearings there are in your machines, the better they will meet the urgent needs of Victory and the economic demands of Peace.

CINCINNATI No. 0-8 Plain Automatic Milling Machine with Automatic Rise and Fall Spindle Carrier. This machine is equipped with 14 Timken Bearings.

If you want your machines to have the utmost in speed, precision, endurance and economy, use Timken Tapered Roller Bearings at every suitable position.

Many manufacturers whose machines previously were only partially equipped with Timken Bearings have been amazed at the spectacular improvement in performance resulting from completely equipping them with Timken Bearings.

The designing engineer is paid to see that his machines are unexcelled in their competitive field, but he is not giving his employer full value unless they not only are *better* machines—but also better *selling* machines.

That means "Timken Bearing Equipped", for no name in bearings has such a strong influence with the machine buyer as "TIMKEN".

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.